APRIL 1956

THE WELDING JOURNAL

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AND SPRING TECHNICAL MEETING

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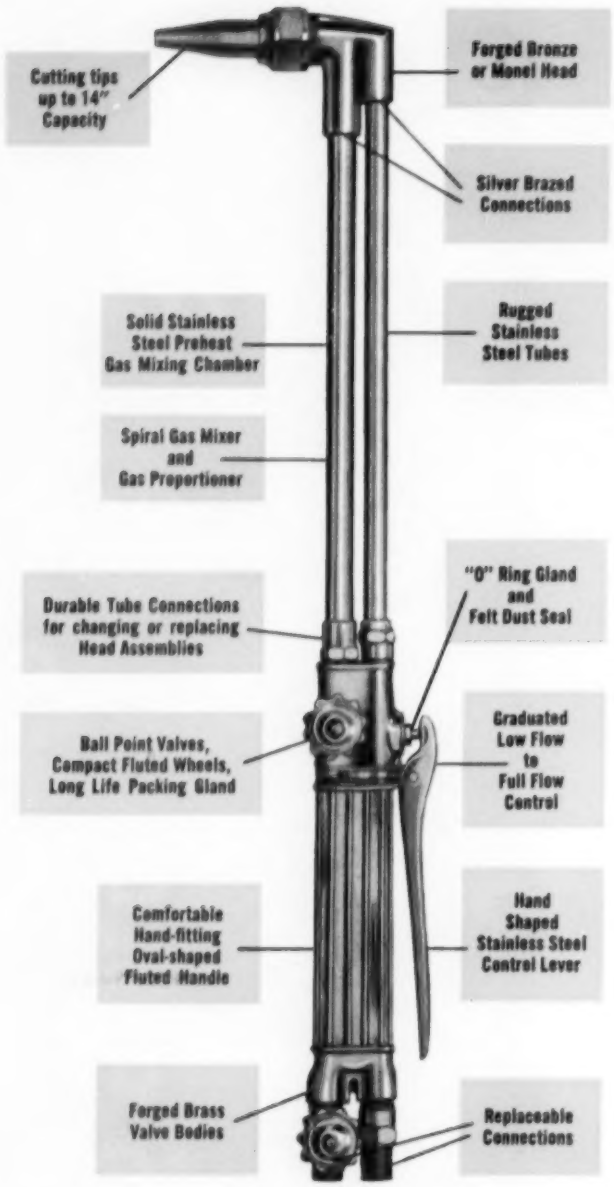
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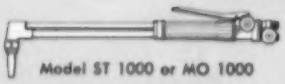
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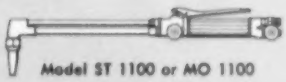
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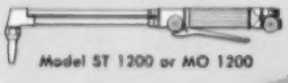
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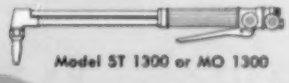
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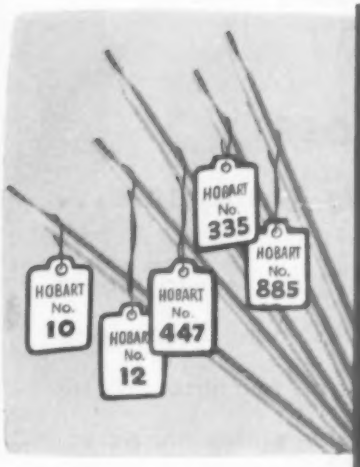

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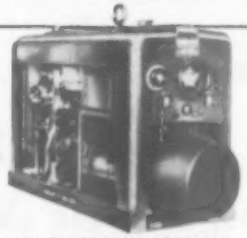

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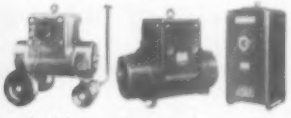

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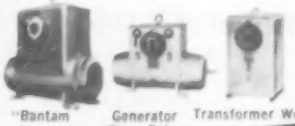

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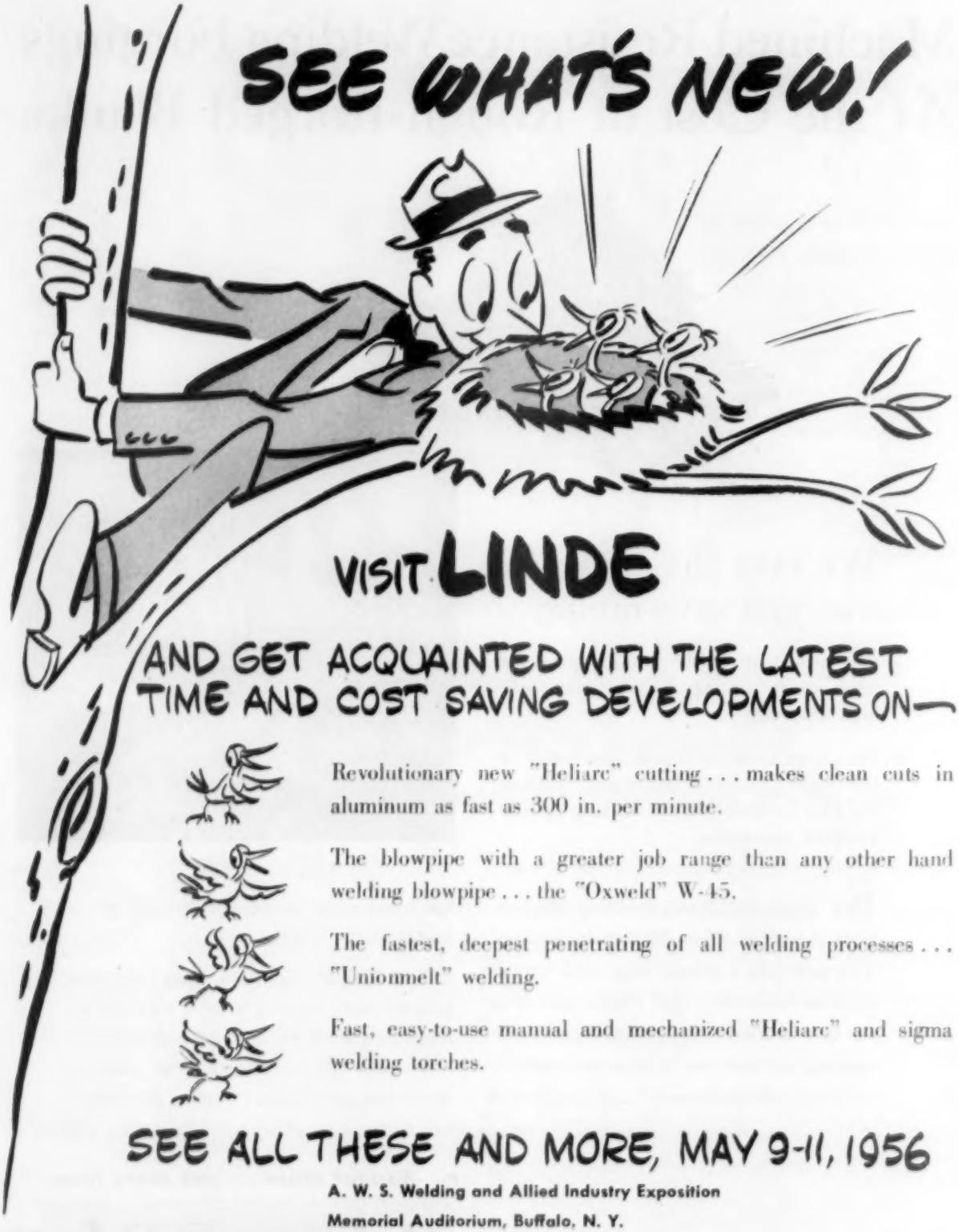

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EDITORIAL

LOOKING FORWARD

The Welding Show has attained its 4th *yearstone*! As 4 joined sides shape a square, so does the 4th welding exposition accomplish a pattern of industrial usefulness. It is a nationally recognized requirement and an internationally established event. Its achievement is a symbol of progress and a marker on the highway of accomplishment along which our industry and our SOCIETY must travel.

Those who have read the lines—and between the lines—of these JOURNALS should be aware of our SOCIETY'S broadening activities. During the past year, readers have been told of our expanded objectives; of our adoption of an exemplary Code of Ethics; of our novel approach to the major problem of producing a flexible 4th edition of the WELDING HANDBOOK; of our explorations into a most promising field—the welding of plastics; of our efforts toward generating greater interest in welding among vocational and engineering students; of our search for ways and means to more extensively promote welded fabrication and the use of welded products; of the expansion of our Sustaining Membership pattern to include organizations as well as individuals; and of our current study of the SOCIETY'S structure for the purpose of bringing forth a new pattern of organization and operation, one which will enable us to even further expand our activities for better serving our membership and our industry.

We live in—and must keep pace with—a go-ahead world. To survive and to progress we must continuously explore new fields of interest and service. When it is evident that new activities will benefit both our membership and industry, we must move forward in the path indicated; we must not hesitate. We must not allow petty isms or indecisiveness to cloud our vision, thus obscuring the vista of opportunity each new day brings forth.

If we steadfastly hold to our objectives with courage and confidence—the heritages passed on to us by the pioneers of our industry and by the founders of our SOCIETY—we will never cease to serve, to grow and to prosper.

J. G. Magrath
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The mark made by a TEMPILSTIK° may gradually change in color as heating progresses. The change in color, or in color intensity, is never to be interpreted as a temperature indication. The TEMPILSTIK° mark melts when its temperature rating is reached and only this change from the dry to the liquid condition is the significant temperature signal.

In some applications this simple method may not suffice because evaporation of the TEMPILSTIK° mark on prolonged heating, or its gradual absorption by the surface at high temperatures, may leave too little residual substance for unambiguous observation. In such cases stroking or touching the work-piece with the TEMPILSTIK° at regular intervals during the heating process is recommended. The TEMPILSTIK° will leave a dry mark at temperatures below its rating and a liquid streak when its temperature rating has been reached or exceeded. If the workpiece is not accessible for applying a TEMPILSTIK° during the heating process, then TEMPILAQ°, or possibly TEMPIL° PELLETS, should be used instead.

TEMPILSTIKS° will usually glide over unheated polished surfaces (like glass, polished stainless steel, etc.) without leaving an appreciable mark. Therefore, in applications that involve smooth or polished surfaces TEMPILSTIKS° should be used by touching or stroking the workpiece periodically during the heating process, as previously described, because a liquid streak will be made on contact as soon as the specified temperature is reached. Where it is necessary to mark a smooth work piece surface prior to heating, TEMPILAQ° should be used.

A hot radiating surface will appear relatively dark under intense illumination from an external source, and this fact can be utilized to improve recognition of the temperature signal against a red-hot background. The use of TEMPIL° PELLETS or TEMPILAQ° instead of TEMPILSTIKS° will further improve visibility under these conditions.

On rapidly moving objects, like magnesium or aluminum sheet during spinning operations, it is impossible to see whether the applied TEMPILSTIK° leaves a dry or melted mark. However, with a little experience operators quickly learn to sense the smooth gliding of a TEMPILSTIK° over a surface which is hot enough to melt it on contact, as contrasted to the frictional drag on a cooler surface. If the top of the TEMPILSTIK° is brought in contact with the moving metal surface for a brief moment at a time, and with light pressure only, the heat contribution of friction is trivial enough to be ignored.

The above described "sensing technique" may also be employed on hot radiating surfaces where the bright background makes it difficult to distinguish whether or not the TEMPILSTIK° mark had melted.

An appropriate series of TEMPILSTIK° marks, applied to the workpiece or surface under investigation before heating begins, will provide a record of the maximum temperature attained during a process or operation. Subsequent examination will show that all TEMPILSTIK° marks up to a certain temperature rating had melted, while those of a higher rating had not. The maximum attained temperature must consequently lie somewhere in the interval between the highest melted and the lowest unmelted TEMPILSTIK° rating.

The temperature distribution and isothermal boundaries of surfaces such as furnace walls, melting ladles, cement kilns, etc., can be established by using an appropriately chosen series of TEMPILSTIKS° to draw a pattern of lines (parallel, concentric, radial, etc.) on the area under investigation. The heat conduction along a surface can be effectively studied by the progressive melting of suitably chosen TEMPILSTIK° lines. Caution must be exercised not to permit the mark made with one TEMPILSTIK° rating to cross or overlap the mark of a dissimilar TEMPILSTIK°, as such a mixing of different TEMPILSTIK° marks would destroy their accuracy.

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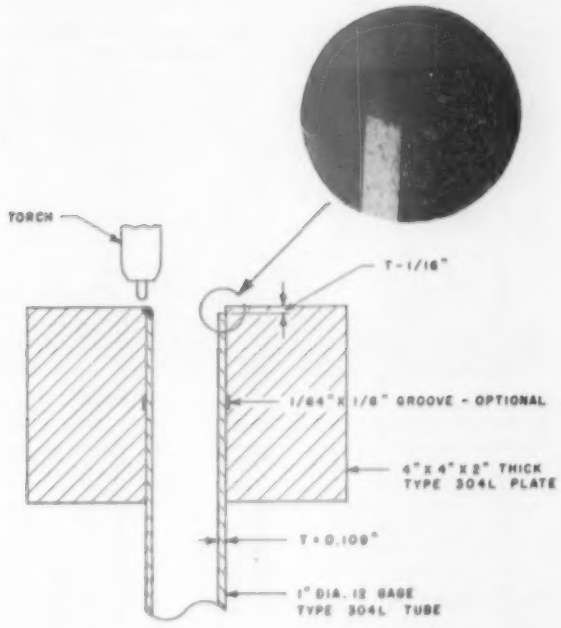

Fig. 1 Weld joint design used for joining 1-in. diam., 12-gage, Type 304L tubes to 2-in. thick Type 304L tube sheets for tubular heat exchangers having the corrosive media on the inside of the tubes. Note the position of the tungsten electrode which fuses the tube sheet material to the end of the tube. Very little of the tube is actually melted and no "roll over" is experienced

JOINING TUBES TO TUBE SHEETS FOR CORROSIVE RADIOACTIVE CHEMICAL SERVICE

BY W. R. SMITH

Suitable joint designs developed for welding tube to tube sheets of heat exchangers where no maintenance repairs can be effected

ABSTRACT. Joining austenitic stainless steel tubes to tube sheets in the fabrication of tubular heat exchangers is a fabrication problem which is particularly acute in the fabrication of heat exchangers for corrosive radioactive chemical process applications where absolute integrity must be maintained and no maintenance repairs can be effected. Joint designs have been developed which are considered to be suitable for welding the tubes to tube sheets for two general cases. In one case, the corrosive solution is in contact with the inside of the tubes; and in the other case, it is in contact with the outside of the tubes. The joints can be produced economically with minimum skills, and can be consistently reproduced with a high degree of integrity and reliability.

This paper includes a detailed description of the joints, the techniques for producing the joints, and mechanical properties of the joints.

W. R. Smith is associated with Hanford Atomic Products Operation, General Electric Co., Richland, Wash.

This work was performed under contract No. W-31-109-ENG-52 for the U. S. Atomic Energy Commission.

To be presented at AWS 1956 National Spring Meeting in Buffalo, N. Y., May 7-11.

Introduction

Joining tubes to tube sheets in the fabrication of tubular heat exchangers is a fabrication problem which has plagued fabricators for many years. This problem is particularly acute in the fabrication of heat exchangers for corrosive radioactive chemical process service where absolute integrity must be maintained and no maintenance repair can be effected. Various designs have been employed in industry which require welding or rolling, or combinations of the two processes to join tubes to tube sheets and all have enjoyed some degree of success for specific applications. Joining austenitic stainless steel tubes to tube sheets by rolling is unreliable since the elastic limit of tubes is essentially the same as that of the tube sheets. The tubes readily work harden from rolling and tight joints are difficult

Table 1—Strength of Tube to Tube Sheet Joints Shown in Fig. 1 by Various Fabrication Techniques

Sample No.	Load at fracture, lb	Calculated tensile stress in tube at failure, psi	Fabrication techniques*
1†	13,700	49,600	W
2	19,350	70,200	W
3	19,400	70,300	W
4	18,750	68,000	W
5	19,450	70,500	W
6	18,950	68,700	W
7	19,500	70,600	W
8	19,050	69,000	W
9	6,900	25,000	R
10	5,650	20,500	R
11	8,050	29,200	R
12	9,300	33,700	R
13	10,250	37,100	R, G
14	6,830	24,800	R, G
15	8,350	30,100	R, G
16	9,450	34,200	R, G
17	19,650	71,300	R, W
18	19,100	69,300	R, W
19	18,900	68,500	R, W
20	18,950	68,700	R, W
21	18,650	67,600	R, W, G
22	18,850	68,300	R, W, G
23	19,200	69,600	R, W, G
24	19,450	70,500	R, W, G
25	19,500	70,700	R, W, R
26	19,900	72,100	R, W, R
27	19,900	72,100	R, W, R
28	20,000	72,400	R, W, R
29	20,100	72,700	R, W, R, G
30	19,600	71,000	R, W, R, G
31	21,100	76,400	R, W, R, G
32	20,250	73,400	R, W, R, G
33	20,950	75,800	W, R
34	21,100	76,400	W, R
35	22,000	79,700	W, R
36	19,100	69,200	W, R
37	19,200	69,500	W, R, G
38	21,150	76,500	W, R, G
39	18,950	68,700	W, R, G
40	20,350	73,800	W, R, G

* W, welded; R, rolled; G, groove.

† Sample No. 1 was welded using a current setting of 140 amp with a resulting small weld bead and insufficient penetration. All other welds were made using 190 amp.

to attain even when very precise techniques are employed. Since corrosive services require the use of stainless steels, some method of welding or combination of welding and rolling is considered necessary.

A poll which was conducted among several leading fabricators of chemical process equipment indicated that there is a wide divergence of opinion as to what is the best and most reliable method for joining stainless steel tubes to tube sheets. Most of the fabricators based their reply on their experience with equipment where occasional joint failures can be tolerated and maintenance repairs can be effected.

Corrosion Media Inside Tubes

Development of Joint

The most common type of tubular heat exchangers are designed so that the corrosive media passes through the inside of the tubes with the steam on the outside of the tubes. Therefore, the first effort was directed to developing a joint which would best satisfy the conditions in this type of exchanger.

Since rolling would not consistently produce a joint having the desired integrity, it was considered that welding or a combination of welding and rolling was necessary to produce the desired joint. Therefore, the first step was to select the most suitable welding process. The inert-gas tungsten-arc process was selected because it was believed that, with tubes having walls less than $^5/_{16}$ in. thick, the welds could be made without the addition of filler metal by using this process. Some requirements of the weld joint were that it could be made with the minimum of welder training and that visual inspection of the weld would provide a reliable indication of the weld quality.

Of the several weld joints which were considered, the one which appeared to be made with greatest ease and reproducibility, as well as the desired integrity, had the tube recessed below the surface of the tube sheet as shown in Fig. 1. The weld is made by directing the tungsten arc on the tube sheet, fusing it to the ends of the tubes with a resulting weld cross section as shown in Fig. 1.

There appear to be several advantages to this weld joint. The minimum section through the weld will equal the wall thickness of the tube if the welding is done in the prescribed manner, and visual inspection can readily determine if such is the case. The weld is made quickly and easily without the addition of filler metal if the tubes have a wall thickness of less than $^5/_{16}$ in., and there appears to be little or no tendency for the weld to crack. The welds can be made in such a sequence that the weld "craters" where the arc is extinguished appear on the tube sheet and not in the weld

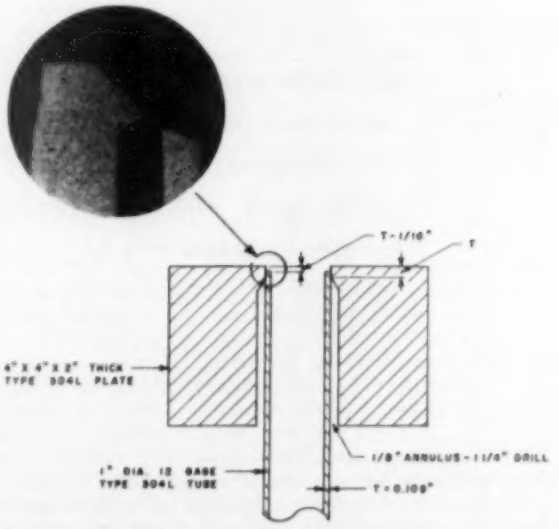

Fig. 2 Weld joint design used for joining 1-in. diam., 12-gage Type 304L tubes to 2-in. thick Type 304L tube sheets for tubular heat exchangers having the corrosive media on the outside of the tubes. The welding is done in the same manner as shown in Fig. 1

joint where they may contribute to a corrosion failure of the joint (see Fig. 4).

Test Results

Once the most suitable joint design for welding was determined, then it was necessary to determine if rolling the tubes in addition to welding would improve the joint.

Forty samples were prepared by five different fabrication techniques to determine the mechanical strength of the joints made by the different techniques. The samples consisted of one-in. diam 12-gauge 304L stainless steel tubes joined to $2^1/_2$-in. thick Type 304L block 4 in. x 4 in. which represented a tube sheet as shown in Fig. 1. The yield point of the type 304L tube sheet material was determined to be 37,400 psi, and the average yield point of the Type 304L tubes was determined to be 37,700 psi. Eight joints were prepared by each of the following techniques:

1. Rolling
2. Welding
3. Rolling and then welding
4. Welding and then rolling
5. Rolling, welding, and then re-rolling

The diameter of the holes in the blocks were 0.005 to 0.010 in. larger than the outside diameter of the tubes.

All rolling was done with controlled torque rolling equipment, and the same torque setting was used for all specimens. The permanent deformation of the tube was sufficient to partially fill the grooves in the tube sheet in those cases where grooves were used.

All welding was done by the inert-gas tungsten-arc process using $^1/_8$-in. diam, thoriated tungsten electrodes

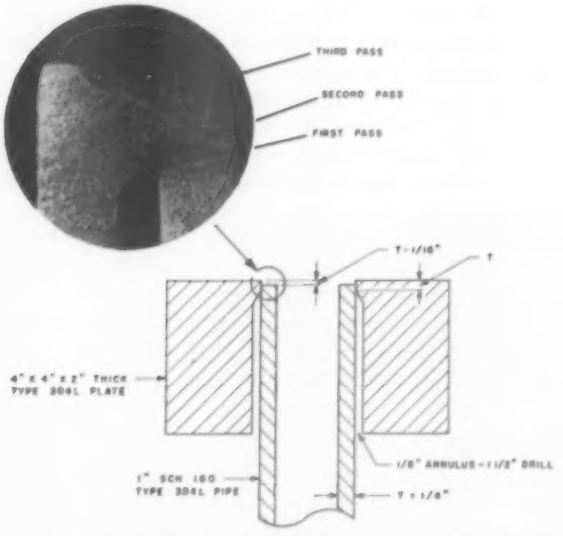

Fig. 3 Weld joint design used for joining 1-in. schedule 160 pipe (¼-in. thick wall) to 2-in. thick Type 304L tube sheets for tubular heat exchangers having the corrosive media on the outside of the tubes. Note the sequence of weld passes to obtain a uniform weld having a cross section equal to the pipe wall

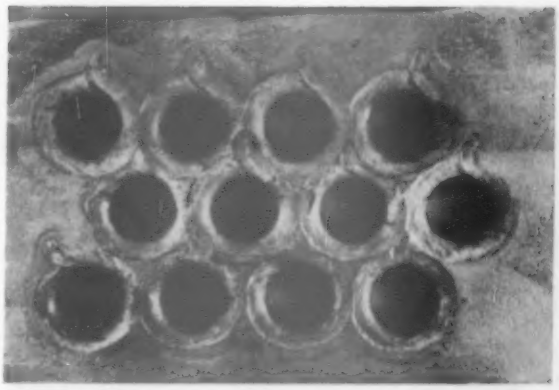

Fig. 4 Photomacrograph of a sample tube sheet using the tube to tube sheet joints shown in Fig. 2. Note that all of the welds can end on the tube sheet so that no "craters" exist in the weld joint

and a current setting of 190 amp. The welding was performed in the same manner previously described.

One-half of all the joints which were rolled were prepared with one groove in the tube sheet and the others contained no grooves.

The results of tensile tests are listed in Table 1. It can be seen from the table that the strengths of the rolled joints varied over quite a large range, and that the grooves did not appear to strengthen the joint by any significant amount. The rolled joints all failed at some load before the yield strength of the tube was attained.

These tests indicated that joints prepared by welding and any combination of welding and rolling exhibited strengths which approached the ultimate tensile strength of the tubes with consistently reproducible results. Rolling prior to welding or rolling after welding appeared to have little or no effect on the strength of the joints. Rolling prior to welding did appear to assist in making the weld as the weld could be made with greater ease and rapidity when the tubes were in close contact with the tube sheet. Also, since the welding can be done most conveniently and most consistently with the tube sheet in a horizontal position, rolling prior to welding can also act as a fabrication aid, as the tubular heat exchanger can be assembled with the tubes in a horizontal position before any welding is performed.

Application of Joint

As a result of this investigation about fifty heat exchangers with a total of about 40,000 tube-to-tube sheet joints (for corrosive radioactive chemical service) have been fabricated by several different fabricators using the above described technique of rolling and then welding. One of these heat exchangers and a tube sheet face are illustrated in Figs. 5 and 6.

Corrosive Media Outside of Tubes

Development of Joint

Tubular heat exchangers which are designed so that the steam passed through the tubes with the corrosive

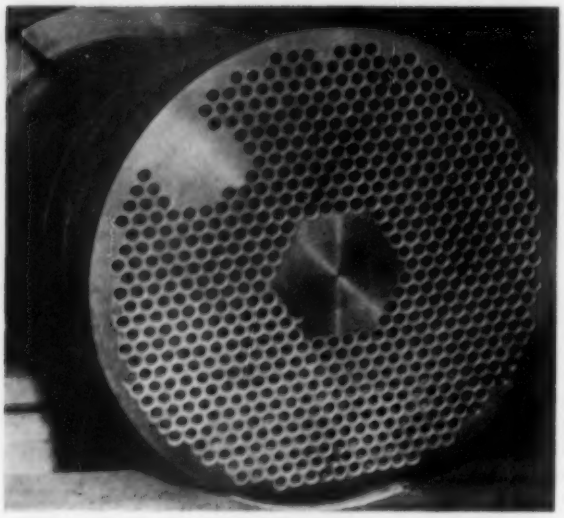

Fig. 5 Photograph of a typical tubular heat exchanger fabricated using the tube to tube sheet joints shown in Fig. 1

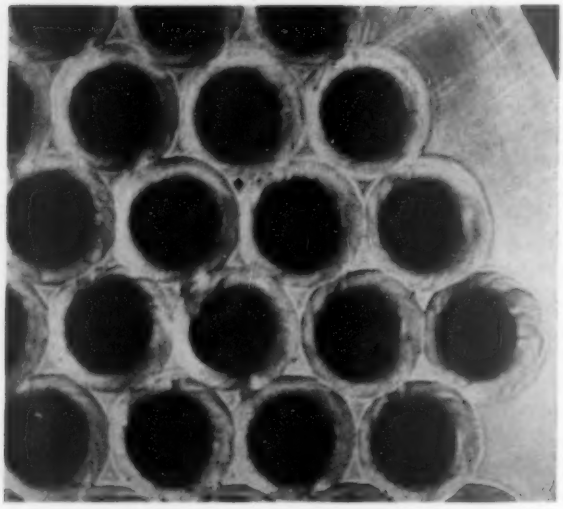

Fig. 6 A close-up view of some of the welds shown in Fig. 5. Note the uniformity of the welds

media on the outside of the tubes present a problem which does not exist in the first case studied. The "crevice" which exists between the tube and tube sheet may cause "crevice" corrosion to occur and lead to early failure of the tubes in many chemical solutions. To eliminate this problem, a joint was designed which would provide an annulus about the tube which would provide for unrestricted passage of liquid in and out of the joint, thus preventing the conditions necessary for "crevice" corrosion to occur. The joint shown in Figs. 2 and 3 provides an annulus about the tube. The tubes are not rolled, but welding is performed in the same manner as it was in the case where no annulus was provided.

Test Results

Four sample joints with an annulus were prepared as shown in Fig. 2, and the strength of the joints determined as shown in Table 2.

Table 2—Strength of Tube to Tube Sheet Joints Shown in Fig. 2

Sample No.	*Load at fracture, lb.*	*Calculated tensile stress in tube at failure, psi*
1	22,100	63,000
2	24,200	69,000*
3	25,000	71,400*
4	21,200	60,900

* The tubes failed in these two cases.

Table 3—Strength of Tube to Tube Sheet Joints Shown in Fig. 3

Sample No.	*Load at fracture, lb*	*Calculated tensile stress in tube at failure, psi*
1	54,800	71,200
2	55,800	72,500
3	55,600	72,200
4	58,000	75,300

Two of the welds failed at a load approaching the ultimate tensile strength of the tubes, and two of the tubes failed before the welds did, indicating that joints of this design have adequate strength for any conceivable application.

Four sample joints were prepared with an annulus as shown in Fig. 3 to determine the strength of joints using one-in. schedule 160 Type 304 pipe as tubes. The weld was made by making three weld passes as shown in Fig. 3. The first pass was made without the addition of filler metal to obtain complete weld penetration, and two passes were made by adding Type 308L filler rod to obtain weld cross sections equal to the pipe wall thickness. The strength of the joints are shown in Table 3, and it is significant to note that the joints failed with a load near the ultimate strength of pipe. These tests indicated that welded tube-to-tube sheet joints made in the prescribed manner will provide adequate strength for any application, and that the joints can be consistently produced.

Pilot plant heat exchangers have been fabricated and operated with an annulus between the tube and tube sheet with no evidence of "crevice" corrosion. Corrosion studies have been made which show the welds to be equally corrosion resistant as the base material without any post-fabricating heat treatment.

Conclusions

These joints can be produced economically with minimum skills, and can be consistently reproduced with a high degree of integrity and reliability.

It is considered that these joints can be employed to advantage for joining materials other than stainless steels. Test units of titanium, zirconium, and fully killed steel tubes and tube sheets have been joined with no evidence of cracking or weld porosity.

HOW TO USE STEEL EFFECTIVELY IN MACHINERY

Welded design makes it possible for the designer to use the right material, in the right amount, in the right place

BY OMER BLODGETT

Introduction

The well-proven advantages of welded construction in machinery of all types are lower costs, better appearance and improved functioning. These advantages stem from the fact that with welded design the designer can put *the right material, in the right amount, in the right place.* Welded design gives freedom to design for function or any other design criteria without the restrictions normally imposed by the casting process.

To help designers realize the advantages of welded design to the fullest, an effort is made here to present certain rules of thumb and short cuts that have been developed in recent years. These aids to designing will lead to using, most effectively, the inherently excellent qualities of steel as a fabricating material. They will help establish the practical extent to which design theory can be carried in placing material to be of the most benefit in meeting requirements of strength and stiffness.

In designing a machine for strength or stiffness, elements must be designed to withstand loads of any one of four types or combinations of these types: tension, compression, bending and twisting. Designing for tension and compression are of a less complex nature than bending and twisting and, therefore, the possibility for improving designs is greater in cases where the latter are involved. The discussion here will be limited to bending and twisting.

Rules for Bending

To use the minimum amount of steel to resist bending:

1. *Place flange material as far as possible from neutral axis and connect flange areas with web material.*

The shape of a section, especially with respect to the location of material about its neutral axis, is most important in using steel effectively to resist bending moments. Figure 1 illustrates how the location of ma-

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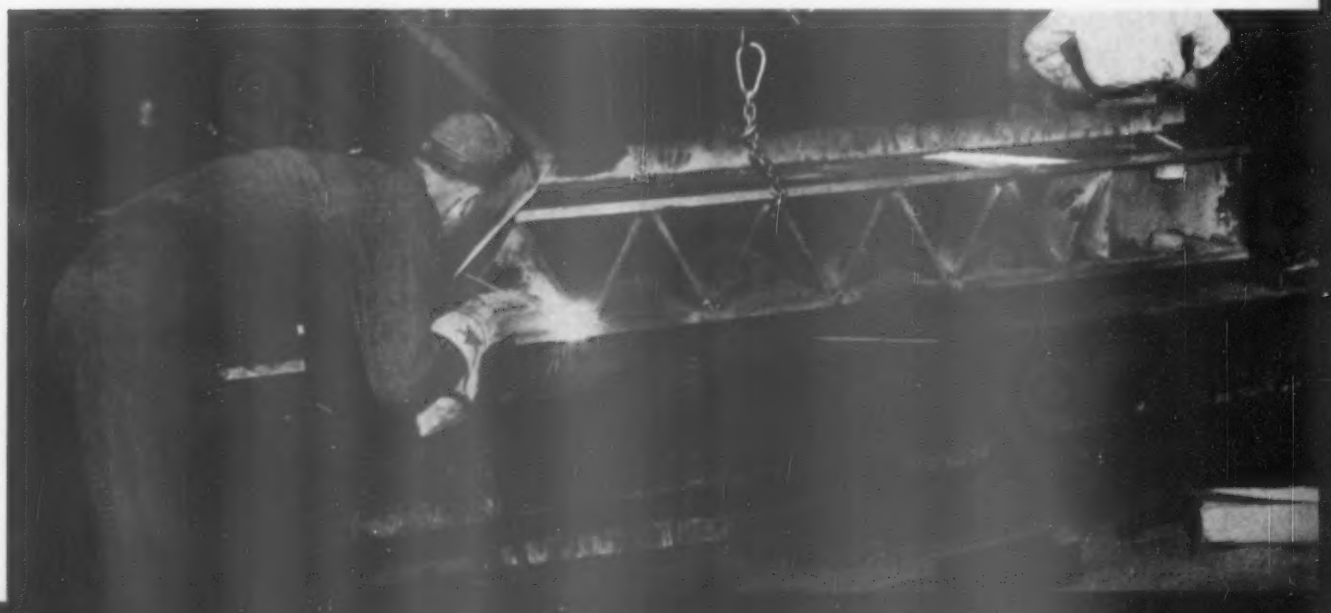
Presented at AWS 1955 National Fall Meeting held in Philadelphia, Pa., October 17–21.

Welding the cross ribbing of a lathe bed



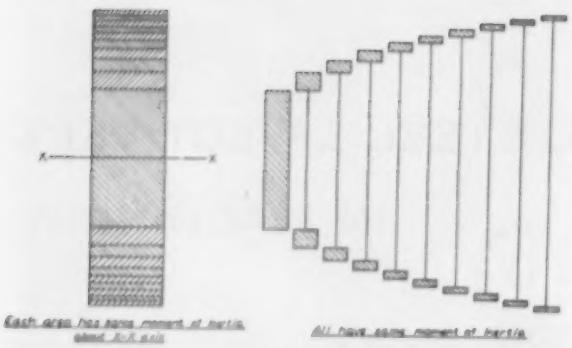


Fig. 1 The thin outer sections of the figure on the left have the same resistance to bending as the thick center section. All of the sections in the figure on the right have the same bending resistance

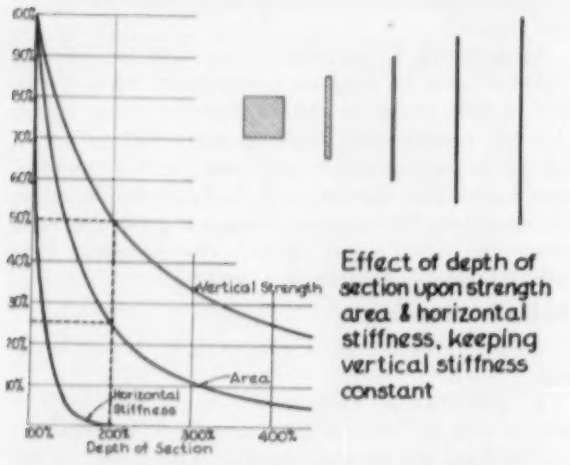


Fig. 2 All of the sections have the same bending resistance, but strength drops off as area is reduced

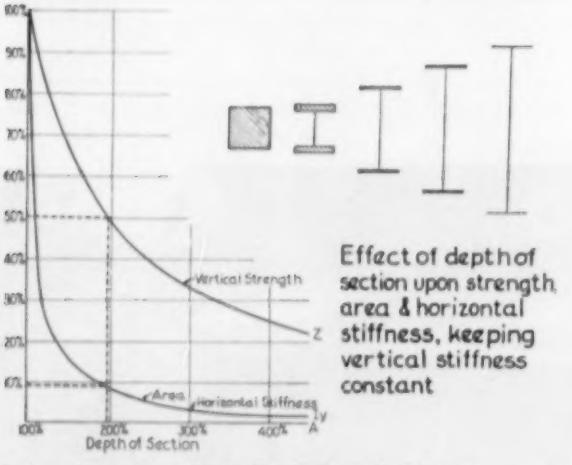


Fig. 3 Flanged sections offer horizontal resistance

terial determines the amount required. The section in Fig. 1 is divided into ten areas, all having the same bending resistance or moment of inertia about the neutral axis of the section. The moment of inertia of a section indicates its resistance to bend. The thin outer area at the top and bottom of the section accounts for 10% of the bending resistance of the whole section. However, the entire center section, representing about 14 times as much material, has the same bending resistance.

Therefore, to place material most effectively to resist bending, put it in flanges as far as possible from the neutral axis. Figure 1 also shows the ten areas of the section projected as flanges. All of these sections have the same bending resistance. As the depth of the section is increased, the required area of the flanges becomes less. This would seem to indicate that deep, thin sections are the best for maximum bend resistance and low weight. Rule 2, however, says:

2. *Do not reduce area below strength or horizontal stiffness requirements.*

In designing a member to meet a certain bending resistance with the least amount of material, practical considerations limit how far sections should be reduced.

All of the sections in Fig. 2 have the same bending resistance, and, as the depth of the section is increased, the required area (A) drops off. But it is important to realize that the strength of the section is also dropping off.

Some of this loss in strength may be tolerated, since usually in a rigid design, the member is much stronger than it needs to be. For example, if the strength can be reduced 50%, then the section can be made 200% of the depth of the initial square section, with an area of only 25%. The only objection to this new section is that its bending resistance in the horizontal direction (see the curve) is almost zero.

Good design practice, to avoid this difficulty, assumes a certain horizontal force along with the given vertical load on a beam. This leads to the use of flanged sections which will not be too flexible or weak in the horizontal direction. The flanged sections in Fig. 3 all have the same bending resistance. Here again, as the depth is increased, the required area drops off. The strength also becomes less. The difference between these sections and those in Fig. 2 is that the area drops

Table 1—Area Required in Different Sections for Equal Bending Resistance

	Area required for $Z = 100$ in^3		Area required for $Z = 20$ in^3	
	about horizontal axis	about vertical axis	about horizontal axis	about vertical axis
width = depth; thickness = ⅛ depth	A = 14.2	A = 20.7	A = 16.3	A = 21.3
I	A = 13.2	A = 21.6	A = 10.3	A = 19.8
⊓	A = 16.6	A = 13.2	A = 16.3	A = 10.3
□	A = 16.2	A = 16.2	A = 12.5	A = 12.5
T width = ½ depth	A = 11.8	A = 41.9	A = 12.9	A = 38.0
I	A = 11.5	A = 33.8	A = 9.9	A = 31.6
⊓	A = 15.5	A = 25.1	A = 14.7	A = 16.3
⊓	A = 15.3	A = 28.1	A = 12.8	A = 18.3
O	A = 16.6		A = 13.9	

off at a faster rate with the same reduction in strength. Again, if a 50% reduction in strength can be had, the depth of the section can be 200% of the initial square section, but the required area is only 9% compared to 25% in the first case. Another important fact is that the horizontal bending resistance is 9% instead of zero. By choosing this section, which makes use of flanges, instead of the simple vertical member, less material is needed for the same bending resistance and strength. The horizontal bending resistance is also much greater.

In fabricating sections to meet both strength and bending requirements with a minimum amount of steel, certain values of moment of inertia (I) or section modulus (Z) must be supplied by the section area. Table 1 illustrates the area required for some nine different typical sections, each having a moment of inertia of $I = 100$ in.^{4}, or a section modulus of $Z = 20$ in.^{3}.

. For stiffness (moment of inertia), the deep I-beam section would appear to be best since its area is only 11.5 sq in. However, a second consideration may suggest using the deep T-beam. The deep T-beam, just above the I-beam in the table, requires an area of 11.8 sq. in. or just 0.3 sq. in. more. Our first impulse is to use the deep I-beam made by welding two flanges to a web, instead of the deep T-beam made by welding one flange to a web, in order to save the 0.3 sq in. of metal.

Just what does this saving of 0.3 sq in. of metal represent?

It represents 1.02 lb per foot of steel saved. At 5¢ per pound, this is a saving of 5¢ per foot. For this saving, we must make use of a second flange. At a labor cost of $2.00 per hour and an overhead of 200% the fabricating cost is $6.00 per hour or 10¢ per minute, hence we can only spend 30 sec. per foot to fabricate this extra flange and save the additional weight.

For strength, section modulus is the governing factor, and it is seen that the deep T-section requires an area of 12.9 sq in. as against an area of 9.9 sq in. for the deep I-beam. In this case (for strength), the greater saving in weight of material would probably offset the additional cost of fabricating and welding the second flange to make the I-beam.

When conditions require equal properties in both directions, about the horizontal axis and vertical axis, the square tubing is best for stiffness with the round tube running a close second. For strength the round tube requires the least area, with the square tube second.

3. *Weld ends of beams rigidly into supporting members to greatly increase strength and stiffness.*

The deflection of a simple beam can be greatly reduced if the ends of the beam are rigidly fixed. The deflection of a beam simply supported on the ends and carrying a concentrated load at midspan can be reduced to $^1/_4$ of its value if the ends are tied in. The deflection of a uniformly loaded beam can be reduced to $^1/_3$. The strength of the beam is also greatly increased.

The beam in the background of Fig. 4 is simply supported on the two upright columns. The sketch just in back of it is the bending moment when it is loaded at midspan with a concentrated load. There is no bending moment at the ends. Maximum bending moment is at midspan. The beam in the foreground is a rigid frame in which the ends of the beam are rigidly tied into the supporting columns. Some of the moment of the beam is carried through the end connection into the column. Although this does introduce some bending moment into the column, it greatly reduces the maximum bending moment in the beam. This reduces the bending stress in the beam as well as its deflection.

Figure 5 shows what happens when both beams are loaded. The simply-supported beam in the background is stressed above its yield point and fails by buckling. If it had not failed, it would have been stressed to 49,150 psi. The rigidly connected beam in the foreground is stressed to only 28,000 psi and is far from failing.

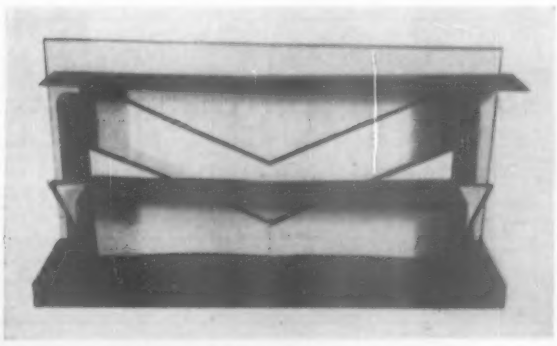


Fig. 4 Simply supported beam and rigid beam with moment diagrams

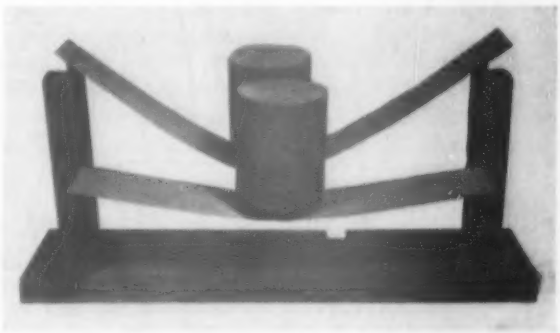


Fig. 5 Comparison of strength of beams when equally loaded

4. *Place joints in low stress areas.*

In a rigid beam, the bending moment passes through zero twice along the length of the beam. These two points are called points of inflection. Because bending moments of these points are almost zero, a joint at this

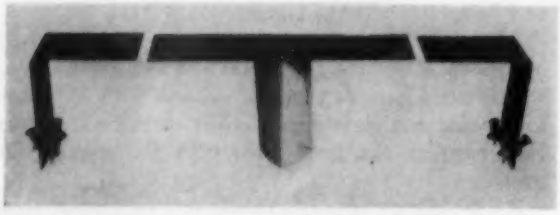


Fig. 6 Beam made in three sections with joints at inflection points

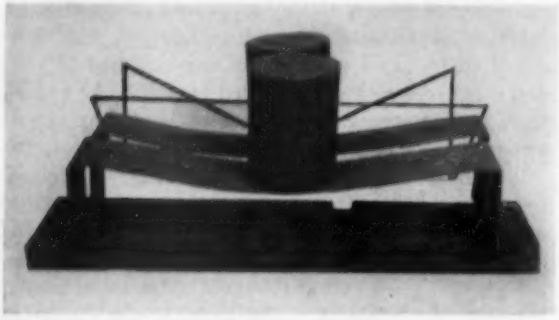


Fig. 7 Comparison under load of three section beam with solid beam. Deflection is identical

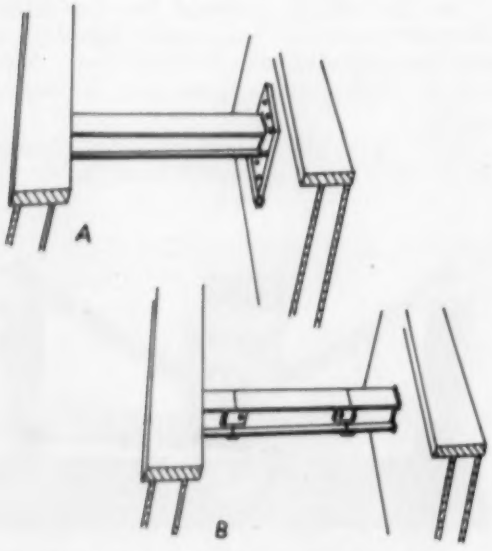


Fig. 8 Simpler joints with equal strength and deflection are possible if placed at low stress points

position does not require much welding, usually just enough to take the shear load. It frequently is practical to fabricate beams of this type in three sections so that the amount of welding can be drastically reduced.

Figure 6 shows such a beam, made in three sections with the joints at the points of inflection. The greatest moment occurs at midspan of the beam and at the ends where it connects to the columns. This beam when loaded identically with a rigid beam having no joint, as illustrated in Fig. 7, exhibits the same strength and stiffness. The mechanical joints at the inflection points, even though not welded for purposes of this demonstration, have no effect on the properties of the beam. Its deflection curve is identical with that of the solid beam.

Figure 8 illustrates the application of these principles in machine design. This cross-supporting bracket must be removable, yet, when in place, must be very rigid. By fixing the ends of the beam into the side members with a rigid end connection, the beam will be 4 to 5 times more rigid than it would be if only simply supported. A mechanical end connection at this point of high bending moment would be very cumbersome (see Fig. 8 *A*). By welding the ends directly to the sides of the base, as in Fig. 8 *B*, and making the joint at the point of inflection, only a single bolt is required to hold this section in place, the main shear load being taken by the small clip welded to the bottom of the cantilever section of the beam. This type of construction would give the same results as a continuous beam welded directly to the sides of the base without any joint.

Torsion

Torsion Problems in Machinery

Normally, twisting or torsion is considered as a load only when designing a shaft. Actually, torsion unknowingly comes into a design quite often. For example, the design of most machine bases depends upon bending. The base is assumed to be supported on its two ends and is designed to carry its load. After the base is made, it is then laid on a good concrete foundation and supported along its length. The resulting bending stresses and deflections are very low.

However, in most cases, this base contains a motor driving some type of equipment. This drive will put the base in torsion and it must, therefore, resist twisting. Normally, the base is not designed to resist twisting because of the difficulty in estimating the results of the twist of the base under load. Yet, if trouble does occur in the operation of the machine,

Table 2—Comparison of calculated with actual angle of twist to illustrate greater accuracy using torsional resistance, R, as against polar moment of inertia, J.

	Angle of twist					
	t=.060 3½	t=.060 2⅜	t=.060 4.15	t=.060	t=.055 2	t=.055 2 2
Conventional method J polar moment of inertia	.01°	.006°	.04°	.04°	.065°	.007°
Method using R Torsional Resistance	9.5°	9.7°	10°	.04°	21.8°	7.3°
Actual twist	9°	9.5°	11°	too small to measure	22°	9.5°

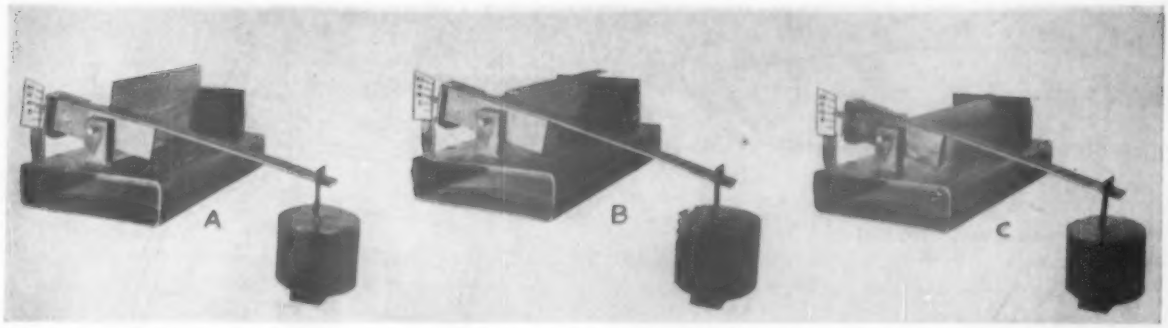


Fig. 9 Torsional resistance of flat plate A is same when formed into channel B, open tube C. When made a closed section by welding, resistance increases

torsion is usually the cause. A good foundation helps to support bending loads on a machine base, but does little to help the base resist twist when loaded in torsion.

Unfortunately, the standard torsional formulas for stress and twist only hold for solid or tubular round sections. Polar moment of inertia (J) is used in these formulas. If this value is used for sections other than round sections, such as I-beams, etc., to find torsional stress and twist, it will give much lower stresses and twist than actually exist. The standard torsional formulas can be used if another value is used in place of polar moment of inertia (J). This value, which should be used for non-circular sections, is sometimes called the torsional resistance (R) of the section.

Rules for Twisting

To use the minimum amount of steel to resist twisting:

1. *Use closed sections where possible.*

It has been found through mathematical analysis as well as experimental testing that the torsional resistance of open structural sections made up of rectangular areas is approximately equal to the sum of the torsional resistances of the separate areas. This means, for example, that the resistance of an I-beam to twist is equal to the sum of the torsional resistances of the web and two flanges. The two right-hand columns of Table 2 list the results of mathematical analysis and experimental testing to demonstrate this principle.

The torsional resistance of a flat plate, therefore, would be approximately the same whether it was used as such or formed into an angle, channel section, etc. This is illustrated in Fig. 9. Samples of different sections, made of 16-gage steel, were subjected to torsion. The flat section (A) twisted 9°. The same piece of steel formed into a channel (B) twisted 9½°. When rolled into an open tube (C), it twisted 11°.

When, however, this same section was made into a closed section by placing a single tack weld in the middle of the open seam, the torsional resistance increased anywhere from 50 to 100 times (see Table 2).

When the tube becomes a closed section, the torsional stresses are distributed more evenly over the

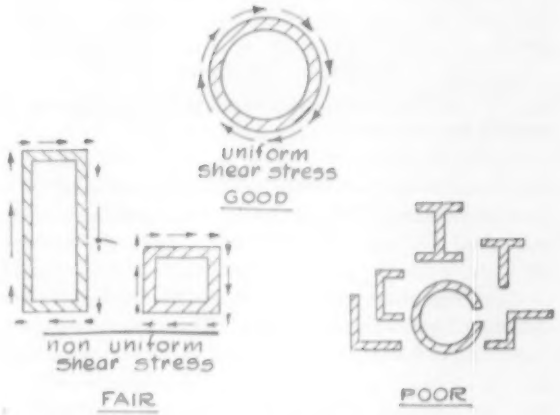


Fig. 10 Recommended sections to resist torsion

total area, thus permitting a greater load. The solid or tubular round section, therefore, is best for torsional loading since the shear stresses are uniformly loaded around the circumference of the member.

Next to a tubular section, the best section for resisting torsion is a square or rectangular tubular section.

The greatest shear stress on any flat surface occurs along the middle. The flat surface closest to the center of gravity of the section has the greatest shear stress. The further away we get from the center of gravity of a rectangular section, the lower is the shear stress. As a result of this, in the case of the square tubing, the greatest stress occurs in the middle of each of the four sides, with a lower stress at the corners. The more this section resembles a rectangular section, the more stress concentration there will be in the middle of these wide flat surfaces.

The poorest sections for torsional loading would be any of the following open sections: flat plate, angle iron, channel section, Z-bar section, T-bar section, I-beam section, and an open tubular section (see Fig. 10).

The principles of torsion which determine the best section for resisting twisting apply equally to built-up frames. As the torsional resistance of a section is approximately equal to the total of the resistance of its

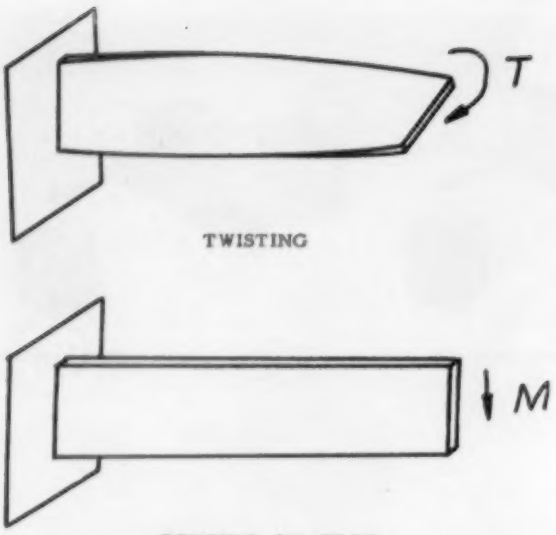


Fig. 11 A flat member has much greater resistance to bending than to twisting

individual areas, so is the torsional resistance of a frame approximately equal to the total resistance of its individual sections. The torsional resistance of a frame whose lengthwise members are two channels would be approximately equal to twice the torsional resistance of each channel section. The distance between these side members for purpose of this example is considered to have no effect. Since the tubular section is best for resisting twisting, the torsional resistance of this frame could be greatly increased by making the channels into rectangular box sections through the addition of plates.

2. *Use diagonal bracing to increase torsional resistance of frames.*

A flat strip of steel has little resistance to twist (see Fig. 11). On the other hand, this same piece of steel when set on edge is extremely resistant to bend. The torsional rigidity of this section, *ER*, is equal to the modulus of elasticity in shear times the torsional resistance of the member. The flexural rigidity, *EI*, is equal to the modulus of elasticity in tension times the moment of inertia of the member.

In the first instance, the torsional resistance of the member depends mainly upon the cube of the thickness of the member; since this thickness may be a fraction of an inch, the cube of this dimension becomes very small. On the other hand, the moment of inertia of this section depends mainly upon the cube of the depth of the section, which in most cases, would be several inches and becomes a very high value.

In the second instance, the modulus of elasticity in shear is much less than the modulus of elasticity of the material in tension.

As an example, the torsional rigidity, *ER*, of a $^1/_2$ in. x 12 in. plate would be 5,400,000; while its flexural rigidity, *EI*, would be 2,160,000,000, or about 400 times better in bending than in torsion.

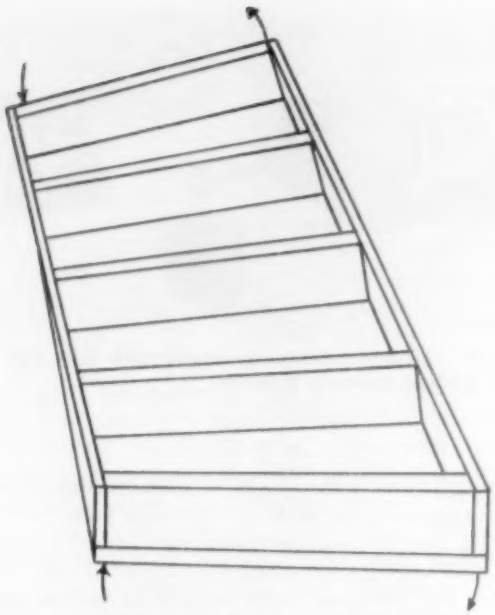


Fig. 12 Individual parts of this conventional base act as flat plates in offering little resistance to twist

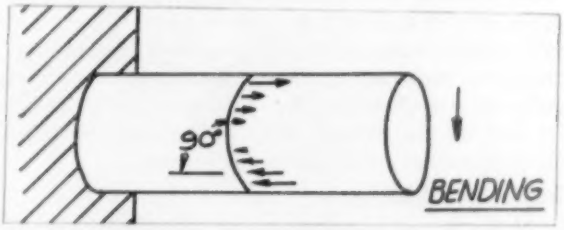


Fig. 13 Tensile stresses from bending occur at 90 deg to the member

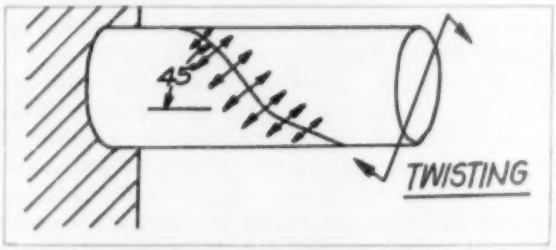


Fig. 14 Tensile stresses from twisting occur at 45 deg to member

This principle affects the rigidity of a machine base when the base is twisted. A base with conventional cross ribbing provides the least resistance to twist, Fig. 12. This is because each cross rib acts the same way as the flat piece of steel subjected to a torsional load. More efficient use of steel ribbing to resist twisting could be realized if the steel strip were placed in bending. To do this, the steel must be placed to take advantage of the internal forces that resist bending and twisting. The direction of these forces can be illustrated in the simple experiment of breaking a piece of chalk.

First, break a piece of chalk by bending. The fracture is 90° with the chalk, because the chalk fails by tensile stresses resulting from the bending (Fig. 13).

Next, twist a piece of chalk until it breaks. The fracture is at 45° to the chalk. Again, the chalk failed in tension, but the plane of the break has shifted to 45° instead of the 90° as before. This illustrates that tensile stresses resulting from twisting lie on 45° planes with the member (Fig. 14).

Machine members, such as bases, therefore, should be braced at 45° to resist twisting with maximum efficiency. By putting bracing at 45°, the bracing is now subject to bending rather than twisting forces. Therefore, when designing a base to resist twisting experience in designing the lengthwise side members for bending is now used to design these diagonal members.

The tests illustrated in Figs. 15, 16 and 17 have been made on scale models of typical machine bases to illustrate the increase in resistance to twist as a result of the diagonal bracing.

The base in Fig. 16 uses conventional cross bracing at 90° to the side members. This particular model under the given torsional load twisted 9°.

Surprisingly enough, a flat plate has approximately the same resistance to twist as a channel section made of this plate. This sheet having the same thickness and over-all dimensions as the previous base and under the same torsional load twisted 10°. This means that a fabricator, as far as torsional loads only are concerned, could have done his customer as much good if he had shipped out a flat plate and mounted his equipment on this plate instead of making a completed base out of the same plate by forming it into a channel section and welding cross ribs to it.

The base in Fig. 16 has diagonal braces at 45° with the side members. It twisted less than $1/4$° and is approximately 50 times as resistant to twisting as the base in Fig. 15, yet it used 6% less bracing material.

Sometimes it becomes desirable to reduce the thickness of the top panel of a base. This can be done by reducing the spacing of the braces which cuts down the length of the unsupported span of the panel. An example of this, comparing diagonal bracing with conventional bracing, is shown in Fig. 17.

This is a test on a scale model of a type bed used for a flat bed printing press. The model on the right has conventional bracing, that on the left has diagonal bracing. Each model is supported on three corners and is

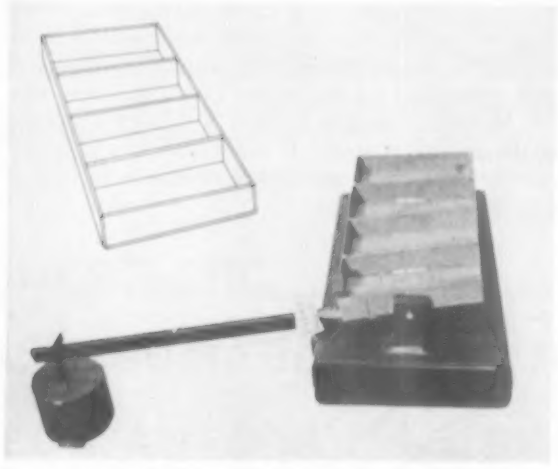


Fig. 15 Model base with 90 deg bracing twisted 9 deg

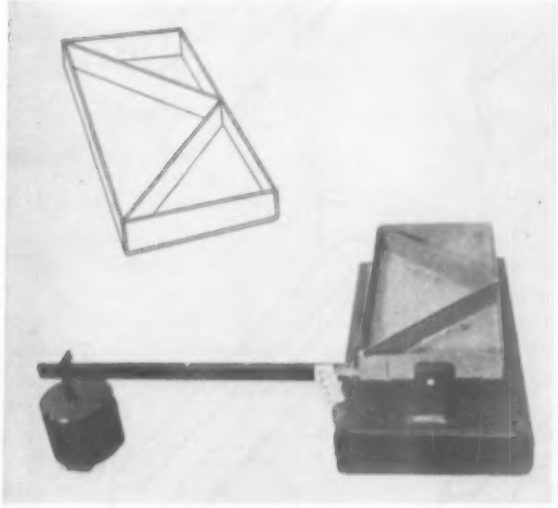


Fig. 16 Model base with 45 deg bracing twisted less than ¼ deg. It is approximately 50 times more rigid than base in Fig. 15 with 6% less bracing material

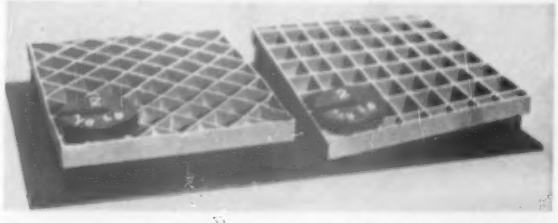


Fig. 17 Models of the beds for a flat bed printing press comparing 90 deg with 45 deg bracing. Reduced spacing allows top panel of base to be lighter

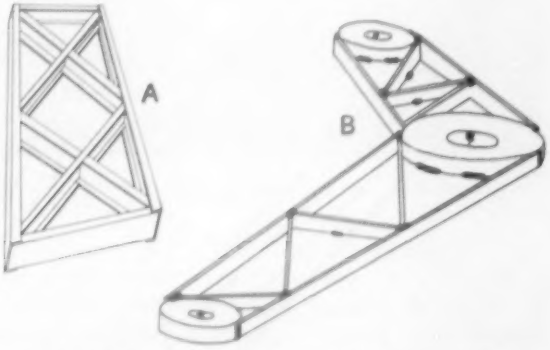


Fig. 18 Applications: A. Frame for farm combine; B. Lever of packaging machine

loaded on the fourth. Diagonal bracing greatly increased the resistance to twist.

Figure 18 shows additional examples of the application of diagonal bracing.

Fig. 18 *A* illustrates still another type of bracing used on a self-propelled farm combine.

The lever shown in Fig. 18 *B* from a packaging machine uses diagonal bracing to give it sufficient rigidity with very light weight.

3. *Make end connections rigid to increase torsional resistance.*

When a member having a noncircular section is twisted, the cross sections do not remain plane but warp (see Fig. 19). It is assumed that these sections are free to warp. The flanges of these members not only twist, but they also swing outward. If the ends of the flanges can be locked in place in relation to each other, this swinging will be prevented and the twisting resulting from this initial bending of the flanges will be greatly reduced.

There are several methods to lock the flanges together (Fig. 19). The simplest is where the end of the member is completely welded to the supporting member. If the supporting member is not thick enough or rigid enough, then a thin, square plate may be welded to the two flanges at the ends of the member. Another method would be to use diagonal braces between the two flanges at the two ends of the member. Either of these methods should reduce the angle of twist by about half.

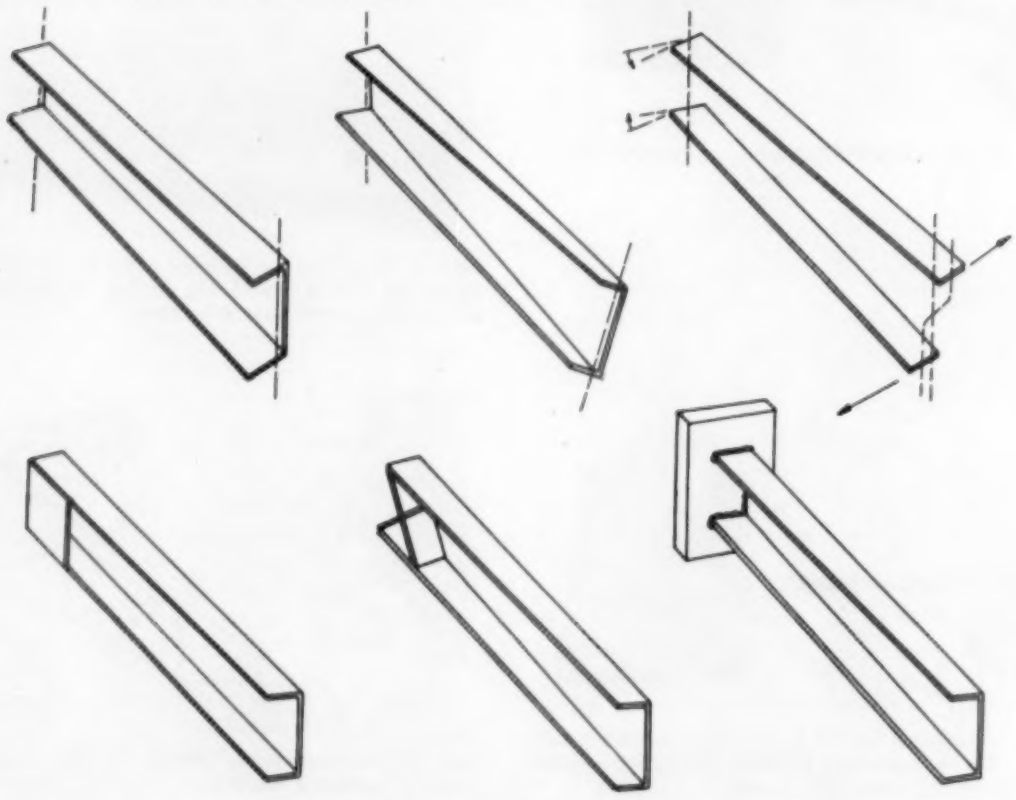
Summary

To use steel more effectively in resisting bending, place flange material as far as possible from the neutral axis and connect the flange areas with some sort of web. However, in reducing the area of the section, it must not be reduced below strength or horizontal stiffness requirements. Flanged sections provide strength in the horizontal direction. Square tubing is best for stiffness about both horizontal and vertical axis.

If the ends of beams are welded rigidly into supporting members, its strength and stiffness are greatly increased, thus permitting the use of smaller sections. Rigid beams also have inflection points of little or no bending moment at which point joints can be made most economically.

Torsion is frequently a factor in machine design. To resist twisting with minimum steel, use closed sections, either round, square or rectangular, wherever possible. Diagonal bracing, rather than plain cross ribs, will increase resistance to twist with only a fraction of the amount of steel. If end connections of a noncircular section are made rigid, resistance to twist is greatly increased.

Fig. 19 (*Top*) Flanges of noncircular open sections rotate with respect to each other creating additional twist. (*Bottom*) Methods of locking flanges together to eliminate the additional twisting



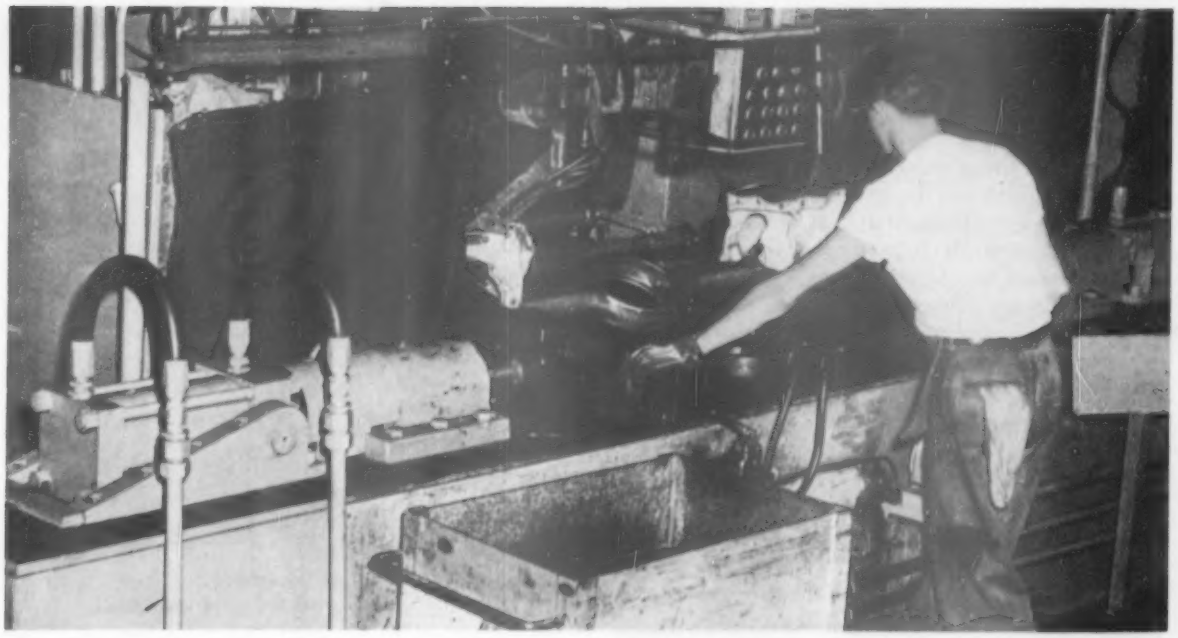


Fig. 1 Rear-axle housing with fitted flanges on each end is moving into position for welding while a welded housing is being ejected from rear of welding machine

INERT-ARC CONSUMABLE-ELECTRODE WELDING FOR AUTOMOBILE REAR-AXLE HOUSINGS

Gas metal-arc process found to be a very satisfactory mass-production tool for carbon-steel welding in the automotive industry

BY E. G. LOMMEL

Introduction

The rear-axle housing of present-day Chevrolet passenger cars is a partially welded, high-production item. As shown in Fig. 2, welds in the finished housing assembly may be difficult to detect at first glance. Nevertheless, there is a welded seam along both sides of the housing over its entire length just as there are numerous other welds—including, for example, a weld joining a cover to the banjo part of the housing.

E. G. Lommel is Plant Engineer, Chevrolet-Buffalo Division, General Motors Corp., Buffalo, N. Y.

Presented at AWS 1955 National Fall Meeting held in Philadelphia, Pa., Oct. 17–21.

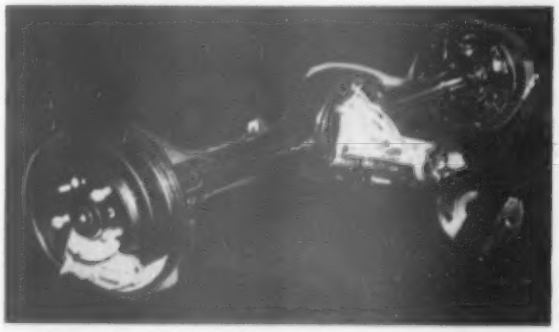


Fig. 2 Cut-away view of assembled rear-axle housing

The body of the axle housing is made from 0.146-in. cold-rolled, carbon-steel sheet stock. It is formed in two halves, which are welded together longitudinally during its initial stages of production. This is done with submerged arc welding. The next step in production calls for the welding of a carbon-steel flange to

each end of the housing. Subsequent welding operations include joining the flange cover to the banjo part of the housing and the attachment of assorted spring, bracket, brake and pipe clips to the housing by means of projection welding.

Attention in this paper is focused on the weld which joins the two flanges to the housing. As can be seen in Fig. 3, this is a circumferential fillet weld. It is one of the more critical welds encountered in the entire operation for making rear-axle housings. It is now being made with *mechanized, straight-polarity inert-arc consumable-electrode welding.* To date, this process has been used in the production of almost 750,000 housings.

Past Difficulties

Prior to adopting inert-arc consumable-electrode welding, the particular weld under discussion was first made with the open-arc process and then with submerged arc welding. Both were mechanized, and results obtained with each left room for improvement. In the case of open-arc welding, net production per welding machine was limited to about 45 housings per hour with a welding speed ranging from 15 to 18 ipm. Porosity along with severe undercutting proved to be a problem; leakage through the weld was another problem.

With the introduction of submerged arc welding, gross production jumped to almost the level now being experienced with inert-arc consumable-electrode welding. Here again, however, difficulties appeared—with a major cause perhaps attributable to the small diameter of the parts being welded. The diameter was such that the flux would sometimes fall away from the parts concerned as they were being rotated during the welding operation. An open arc would result, causing a marked degree of weld porosity. There were other difficulties too. For example, it was occasionally difficult to remove the flux for inspection purposes. As another example, starting failures were sometimes encountered which caused electrodes to stick to the work and pull welding heads out of alignment.

Over-all results obtained with these processes were the same in one respect: This particular welding operation was a bottleneck in the production of rear-axle housings. Although true that different techniques, conditions and fixtures might have eliminated difficulties experienced with each, a decision was made to go elsewhere for a solution to the problem of how best to weld flanges to each end of the housing.

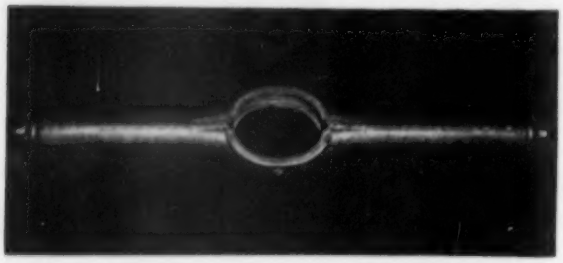


Fig. 3 Axle housing with flanges welded to end

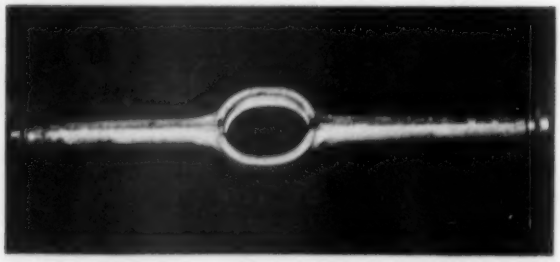


Fig. 4 Axle housing with flanges prior to positioning over each end

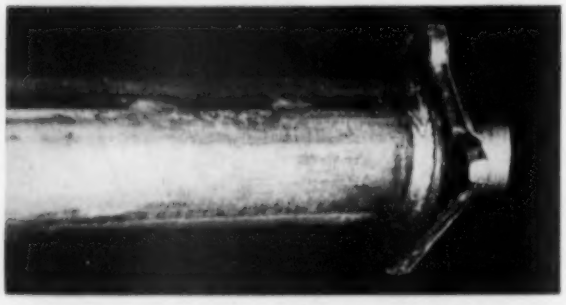


Fig. 5 Close-up of housing with a flange welded on at one end

Solution to Difficulties

Job Objectives

In seeking a solution to previous difficulties, certain job objectives were established. These objectives are discussed below under separate headings:

1. High-speed production. This, of course, was an obvious objective.

2. Simplicity of operation. Prior to the fabrication of rear-axle housings for 1955 model automobiles, an operator was required to position each housing in a welding machine—and when welding was done, to take it out again. It was desirable to design welding machines for pushbutton, straight-through operation wherein a housing would be automatically ejected after the end flanges had been pressed on and welded to the housing.

3. Weld properties. The weld was required to be leakproof and structurally strong—and in being structurally strong, the weld had to be stronger than before. It had to be strong enough to take the full torque of the new V-8 engine as well as the full torque of braking which has become much more critical in that cars are now capable of exceeding a road speed of 100 mph.

4. Trouble-free process. This was a necessary objective if previous difficulties were to be overcome.

5. Cost. As a result of previous welding difficulties, it was not possible to attain a production efficiency greater than 60%. In view of cost savings that would ensue, it was desirable to increase this ratio to 100%.

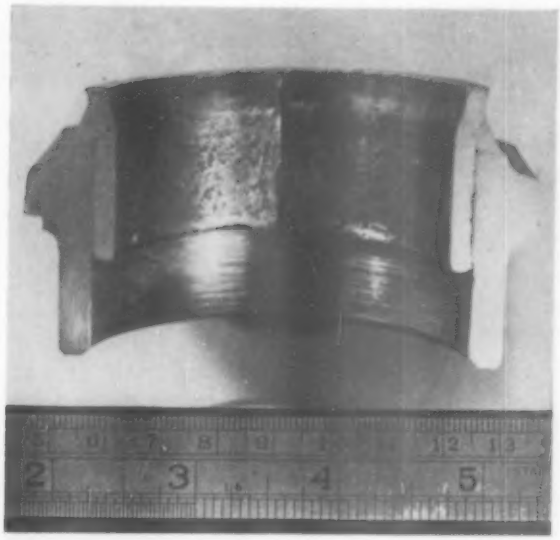


Fig. 6 Cross section of weld joining flange to housing

In other words, this machine which was designed to produce 150 housings per hour (gross) or a net of 105 per hour, was only netting 60–65 per hour.

Selection of Welding Process

After laboratory and road proving-ground tests, inert-arc consumable-electrode welding was selected as the one process which seemed to offer the best possibilities for eliminating past difficulties and for meeting job specifications. When eventually selected for production purposes, it was and continues to be used for welding a forged 1020 carbon-steel flange to each end of a 1010-1008 cold-rolled carbon-steel housing. A disassembled view of the two flanges and housing is shown in Fig. 4. Prior to welding, the flange is pressed onto and over the end of the housing.

Referring to Fig. 1, the sequence of operations is briefly as follows: First, the operator places the two flanges in retainers which are part of the welding machine. Having done this, he then positions a housing in the welding machine and mechanically presses both flanges over each end of the housing. After doing this, he pushes a button which actuates an automatic mechanism for moving the housing with flanges into place for welding. Welding then occurs automatically while the operator places two more flanges and another housing into their initial position. By pushing the same button again, the operator automatically causes the welded housing to be ejected from the welding machine while, at the same time, the next housing with flanges fitted over each end moves into welding position.

Results

Results obtained with inert-arc consumable-electrode welding are now entirely satisfactory and can perhaps best be summarized in terms of original job objectives:

1. High-speed production. Gross production for each welding machine has increased to 150 housings per hour. Net production has similarly been raised to 100–105 per hour.

2. Simplicity of operation. The handling of housings has been reduced to a minimum; and welding, itself, is in effect a "push-button" operation. The operation has been further simplified due to the ease with which welds can afterwards be inspected visually. Finally, the operator is no longer required to handle or adjust flux-handling equipment which was previously required with submerged arc welding.

3. Weld properties. Weld appearance has been important in that welds are inspected visually for proper weld location as well as for external evidence of incomplete penetration and surface "volcanos" or so-called worm holes. In this respect, welds made with the inert-arc consumable-electrode process have been entirely satisfactory as can perhaps be seen from Fig. 5.

Figure 6 illustrates the cross section of a typical weld made with inert-arc consumable-electrode welding. Close study shows that welds made with this process are porosity-free. Close study also shows a high degree of fusion between the weldment and base metal. The result is a weld that is leakproof with respect to grease and has an average shear strength of about 75,000 lb.

4. Trouble-free process. In its present form, the inert-arc consumable-electrode process has been most satisfactory in that difficulties encountered with prior methods have been eliminated. For example, equipment-maintenance troubles associated with the use of an abrasive flux are no longer a problem; and, similarly, "volcanos" or worm holes are no longer found in welds.

As originally installed, the inert-arc consumable-electrode process was installed with motor-generator sets and controls. These were found to be rather unsatisfactory because of two reasons: First, the slow build-up of power in those sets caused welding wire to stick to the work. Second, the high open-circuit voltage of these sets caused frequent burn-backs at the tips of welding guns.

These problems were overcome by replacing the original motor-generator sets with a constant potential, rectifier-type of power supply. Similarly, proper shielding overcame shielding problems which were initially associated with this particular application of inert-arc consumable-electrode welding. Laboratory experimentation gave the answers to questions dealing with welding conditions.

As final evidence of the success of this process, rejects are now limited to about 0.5% of total rear-axle housing production.

5. Cost. As measured in terms of consumable materials, the cost per housing is now 7.25 cents:

Wire	3.34¢
Argon	3.91¢
Total Cost	7.25¢ per housing

Cost *savings* resulting from the change-over to inert-arc consumable-electrode welding have been far-reaching. In the first place, this welding operation is

no longer a bottleneck in axle production. Secondly, over-all efficiency has increased from about 60% to the looked-for 100% figure.

Details of Welding

Equipment Requirements

The equipment required for this application of inert-arc consumable-electrode welding cannot operate without an adequate supply of shielding gas. In this application, the shielding gas is a mixture of 98% welding argon and 2% oxygen. (Although any description of the function of the oxygen is beyond the scope of this paper, its presence is necessary when using straight-polarity current for welding carbon steel with the inert-arc consumable-electrode process.) The argon-oxygen mixture is supplied by pipeline from the bank of manifolded cylinders in Fig. 7.

Excluding the welding fixture, specific items of equipment are as follows: First, there is a power-supply unit, which is a constant-potential, rectifier-

Fig. 7 Manifold argon cylinders (containing 2% oxygen for straight-polarity welding)

type direct-current power source. An exterior view of this unit is shown in Fig. 8. Then there is a wire-drive unit consisting of wire on a reel, controls, and a drive motor to feed the wire to a water-cooled welding torch. In this application, there are two wire-drive units and two torches for each rear-axle housing welding machine. Each torch is mounted in a fixed position over the work, which is automatically rotated during welding.

A complete wire-drive unit may be seen in Fig. 9. As shown in this illustration, the wire drive unit is mounted at the top of the welding machine, with the wire reel being attached to the upper part of a box containing the controls while the drive motor is attached to the lower portion of the box. The drive motor shown here is essentially a direct-current shunt motor with two gears driving a set of rollers which pull the wire from the reel. The action of the motor is governed by sequence controls consisting of necessary relays

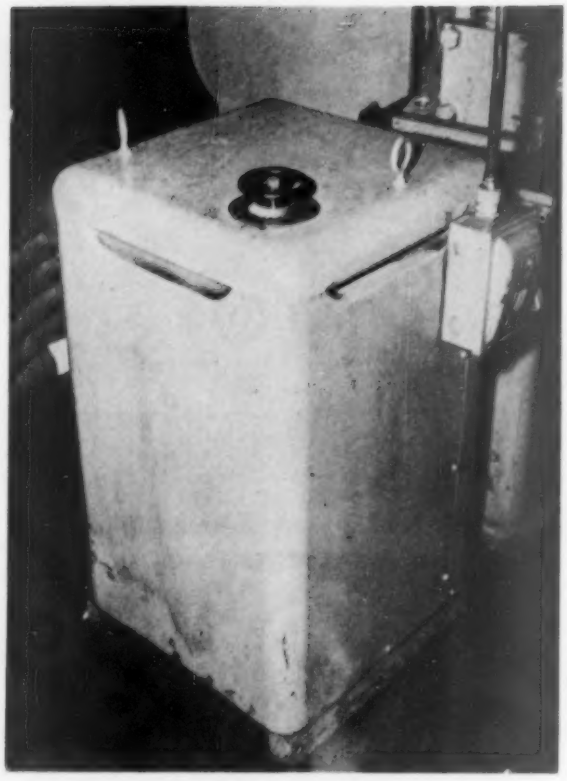


Fig. 8 Exterior view of constant-potential power-supply unit

mounted in the control box for starting and stopping the motor. Sequence controls in the control box also include solenoid valves to start and stop the flow of water used for cooling the torch, and to start and stop shielding-gas flow to the torch.

Wire, which is pulled from the reel by the drive motor, is fed to the work through the guide tube of the welding torch, shown disassembled in Fig. 10. In like fashion, water and the shielding gas flow through separate tubes to indicated water and gas connections on the torch. (A third tube carries water from the torch.)

One of the most essential parts of each welding machine is the fixture. Locating the flanges on the housings at the proper point, transferring the housing with flanges into position for welding, turning the housing at the proper welding speed, and finally ejecting welded housings through the back of the welding machine—these are functions of the fixture.

Welding Conditions

In this application, the relationship of the welding torch to the work is a critical factor with respect to the success of welding. As shown in Fig. 11, the torch is 45 deg downhill from the top of the housing and slanted 45 deg to the face of the flange. The tip of the nozzle is $^1/_2$ in. from the work. This $^1/_2$-in. dimension is very important for two reasons. First, if the tip was closer to the work, spatter from the work would clog the nozzle. Second, if the torch was farther away from

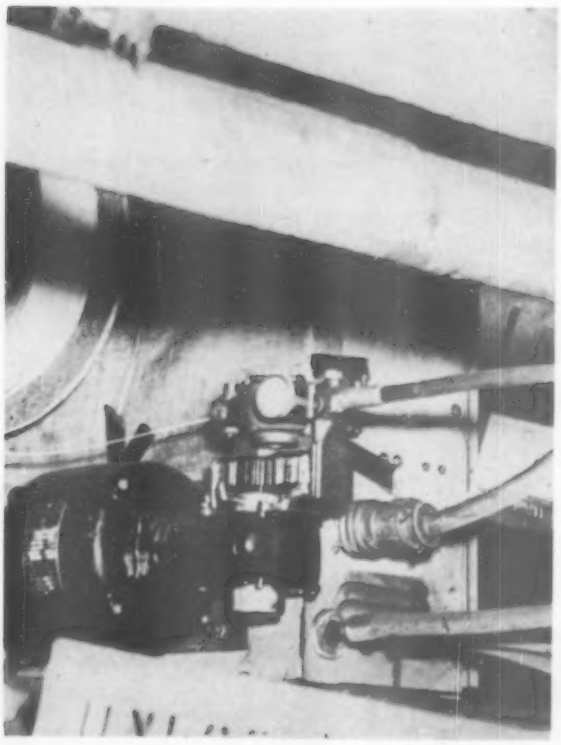


Fig. 9 Wire drive unit (wire reel and drive motor attached to control box)

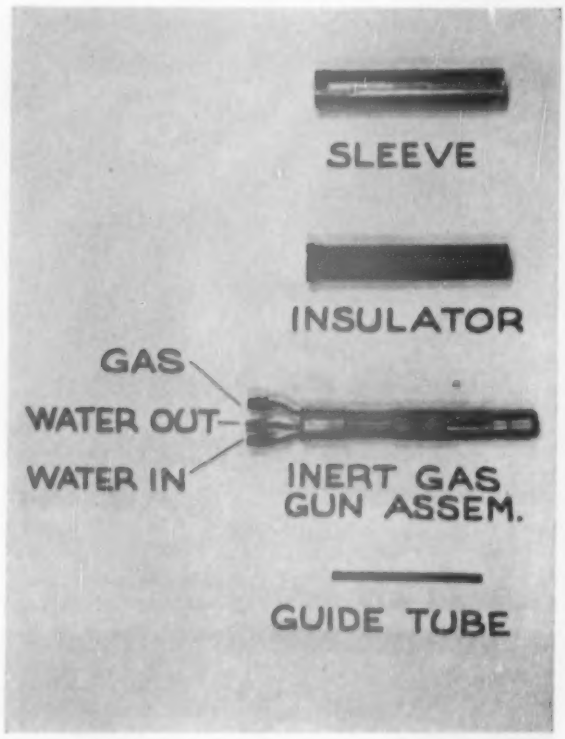


Fig. 10 Disassembled welding torch

the work, poor welds might result due to inadequate gas shielding. At this dimension, the effects of spatter are practically nonexistent and gas shielding is adequate.

As stated previously, the shielding gas is a mixture of 98% argon and 2% oxygen. Gas flow to each torch ranges from 25 to 30 cfh—or a total of 50 to 60 cfh per welding machine. Corresponding current and voltage conditions are as follows: straight polarity, direct current—400 to 420 amp; arc voltage—25 to 25½ v; open circuit—28½ to 29 v.

The wire used in this application is wash-coated with a metallic oxide, which helps to stabilize the arc and modifies the wire burn-off rate in straight-polarity welding. It is 1/16 in. in diameter and, at 420 amp, is consumed at a rate of approximately 25 fpm.

Operation of Equipment

As previously indicated, the first step on the part of an operator is to place a housing into the welding fixture and to locate a flange at each end of the housing. The next step is to press the flanges onto the housing. This is done through pressure exerted by a hydraulic cylinder as it pushes against a cast-iron block, which in turn forces the flanges onto the housing. There is a cylinder and block at each end of the housing, and adjustable nuts between each cylinder and block control the distance each flange moves as it is being pressed into position on a housing.

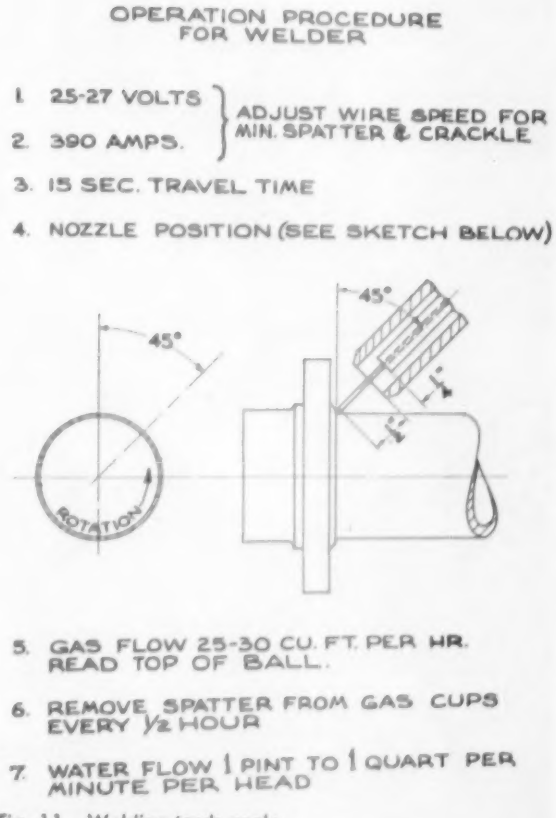

OPERATION PROCEDURE FOR WELDER
1. 25-27 VOLTS
2. 390 AMPS.
ADJUST WIRE SPEED FOR MIN. SPATTER & CRACKLE
3. 15 SEC. TRAVEL TIME
4. NOZZLE POSITION (SEE SKETCH BELOW)
45°
45°
ROTATION
5. GAS FLOW 25-30 CU. FT. PER HR. READ TOP OF BALL.
6. REMOVE SPATTER FROM GAS CUPS EVERY ½ HOUR
7. WATER FLOW 1 PINT TO 1 QUART PER MINUTE PER HEAD

Fig. 11 Welding torch angle

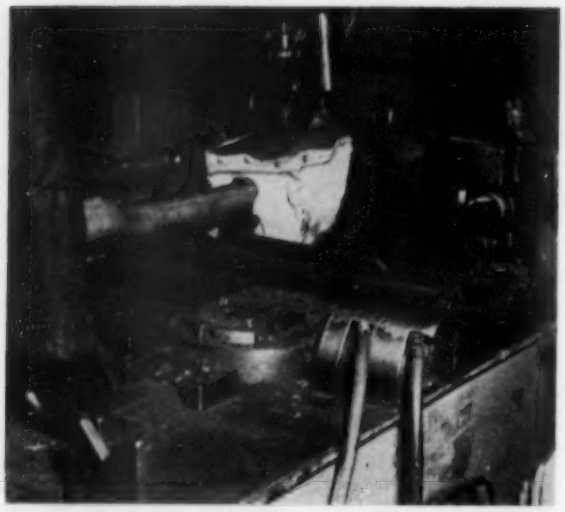


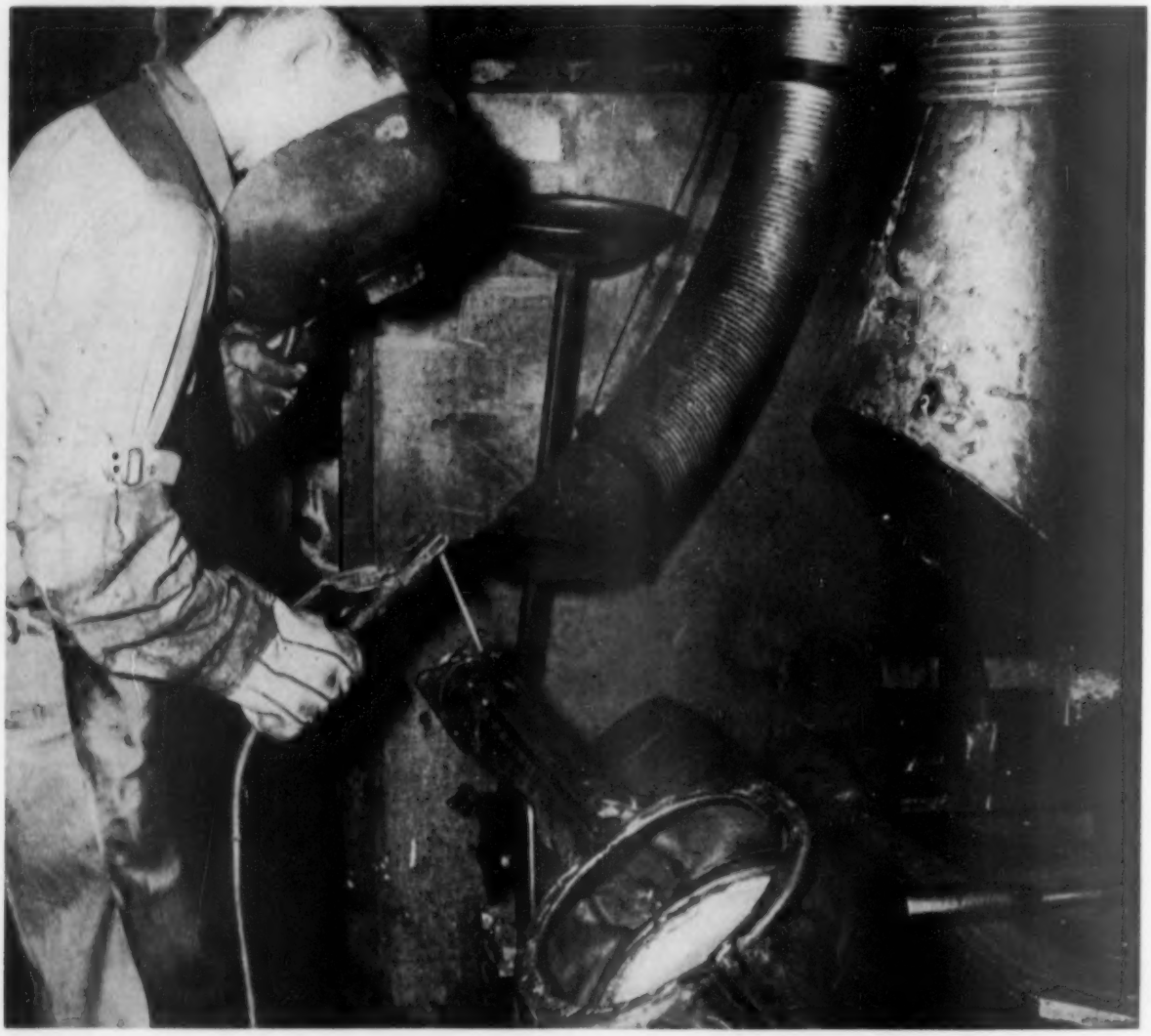
Fig. 12 Close-up of fixture

When each flange is properly located on the housing, pushing a transfer button moves the housing with flanges into welding position. After the transfer mechanism has returned to normal position, platens move down over the work and make up a limit switch. At this point, the wire-feed motor inches wire down to the work. As the wire makes contact with the work, it energizes a relay that starts the sequence of operations in the control box. This opens the water- and gas-control valves, and throws the drive motor into its action of feeding wire at a rate of approximately 25 fpm. Welding is timed by synchronous timer. At the proper time, the timer cuts off the wire drive motor, which is stopped by dynamic braking. The platens then retract and wait for the operator's next signal.

Fixture Design

Locating the two flanges on each end of a housing was found to be one of the most critical steps in the whole operation.

Fig. 13 Operator in visual testing and repair booth



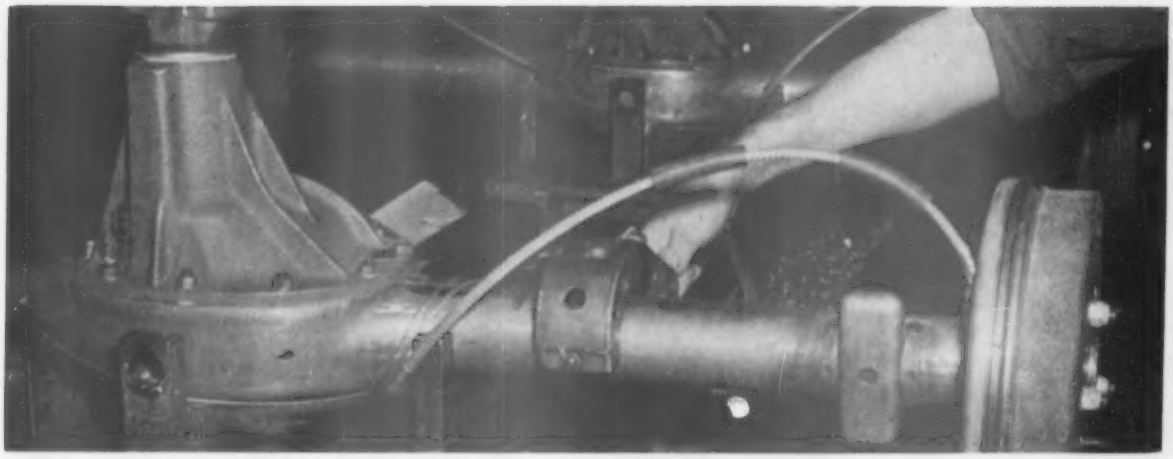


Fig. 14 Air pressure test (test gage mounted on axle housing)

(1) If the flange was pressed on too far, all the weld would be on the flange and it would not be fused with the housing. If the flange is not pressed on far enough, it would be possible to scrap the entire housing because of burn through.

(2) The positioning of each flange is maintained to within ±0.020 in. A total pushing effort of 15,000 lb is supplied by 7-in. hydraulic cylinders with a pressure of about 400 psi. As will be noted from Fig. 12, there is a heavy block to the far left of the fixture and another block to the far right of the fixture—with hydraulic cylinders (not shown at the left) activating both blocks.

(3) These blocks carry the details that position the flange axially on the housing and also the pilot to guide them onto the housing.

(4) The housing is held in position for the pressing operation by a center locator with expanding location points. Initially these points contacted the housing at four widely separated areas, but it was found that when the press fit approached the maximum of 0.015 in., the housing would spring too much and sometimes even split at the longitudinal weld seam. In order to eliminate this difficulty, a radius type locator was designed to match the curvature of the banjo ID and to be as close to the centerline of the housing as possible. This locator is expanded by a wedge operated by an air cylinder.

Leakage Tests

Prior to any testing for leaks, a cover is welded to the banjo part of the housing with the submerged-arc process immediately after the two flanges are welded onto each end of the housing. After this operation, testing is carried out in two stages. First, the welded housing is visually inspected for readily apparent weld imperfections. Later, the completed axle housing is subjected to a final air-pressure leakage test.

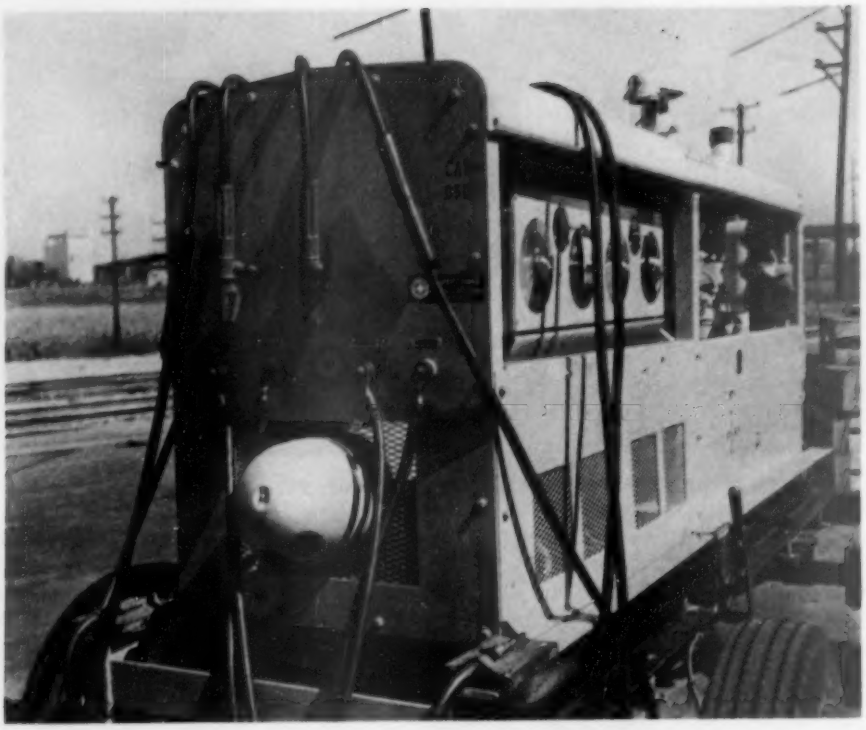
As shown in Fig. 13, all housings are visually inspected by welders in booths and repaired at this point. Repairs consist of adding additional filler metal to welds that show external evidence of incomplete penetration or that have surface holes. Originally, the housings were submerged in water at this point, and the welds were checked with air under pressure. However, it was found that, with inert-gas consumable-electrode welding, the welds were either completely sound or the holes were so apparent that 90% of any defective welds could be repaired without submerging in water and then 100% checked on the line with air except for any welds that might have been missed by the operators.

Fig. 14 shows the setup used for the final air-pressure test. With this setup, all completed rear axle-housing assemblies are checked 100% on the assembly line for leaks. This is done by clamping an air fixture over a breather hole on the housing and filling with air at a pressure of approximately 20 psi. The air is then shut off, and the leak-down is measured over a definite time interval. If the leak-down is faster than anticipated, the inspector immediately checks for leaks by turning the air back on and checking with his hand to discover where air is escaping from the housing. As soon as this leak is found, the housing is tagged and taken off the assembly line into a repair area where leaks are repaired.

Approximately 7 to 8 out of every 1400 housings are rejected each shift with the 100% check on the line. However, not all of these are rejections because of weld leaks in that seal leaks contribute a great portion of these rejections. In addition to leaks which may occur through the longitudinal-seam and end-flange welds, leaks may occur at the axle shaft seal, the pinion shaft seal, and the gasket around the joint where the carrier is mounted on the banjo.

Conclusion

The use of inert-gas consumable-electrode welding for rear-axle housings is one of the first applications of this process in the automotive field. Under the conditions outlined here, this process has proved a very satisfactory mass-production tool for carbon-steel welding. Furthermore, its use has eliminated difficulties formerly experienced with other welding methods.



Keys to efficient welding circuit maintenance are shown here. These include welded copper joints, vulcanized insulation covering and lock-type quick connectors

EFFECTIVE WELDING CIRCUIT MAINTENANCE

Careful analysis of maintenance problems, coupled with limiting of material and operating costs, enables plant to set a record for efficiency and cost control

BY DONALD L. CALDWELL

An effective program of welding circuit maintenance, initiated in 1951 at Caterpillar Tractor Co. in Peoria, Ill., and now virtually complete, has resulted in continued savings averaging approximately $1200 per month (see Table 1). Careful analysis of the ever present problems of maintaining quality yet limiting material and operating costs has enabled us to set a record for efficiency and cost control. How this was accomplished is worth recording; it is important information for all other companies faced with similar maintenance problems. Because of the heavy machinery used in fabrication of road building equipment, one of the most serious cost problems encountered by our company was its inability to salvage the considerable quantities of welding cable damaged in the shops.

Various methods of splicing damaged sections were tried and discarded. Some were unsatisfactory from a standpoint of conductivity. Others were dangerous from a safety standpoint. Those which were reasonably efficient were far too costly for regular use.

Another serious problem was the effect on welding quality which resulted from current loss due to poor conductivity in welding circuits. Not only cable, but also holders, connectors and ground clamps heated up

Table 1—Analysis of Savings Effected

1.	Salvage 96% of cable formerly discarded	$ 900
2.	Lowered maintenance labor costs 50%	
3.	Reduced quick connector maintenance costs 65%	
4.	Reduced ground plate cost and increased life 300%	$ 300
5.	Increased electrical efficiency 15%	
6.	Increased operator efficiency because of heat-up elimination in circuits and holders	
7.	Elimination of safety hazards	
Savings per month		$1200

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excessively. This heating and subsequent cooling caused weakening at connections which, in turn, caused frayed and broken cables. In the case of soldered joints,excessive heating-up caused the solder to melt out. Clamp joints loosened, causing arcing and subsequent current loss. All of this necessitated continual maintenance.

In addition to actual cost involved, the more serious problem of operator discomfort was an important factor. During production welding on heavy jobs it was necessary for operators to use two holders and alternate them as each became too hot to handle. In addition to the double cost involved in the use of multiple holders, the men also needed buckets of water in which the hot holders were left to cool. This added considerably to maintenance by causing severe corrosion of cable strands at holder connections and thus necessitated too frequent repairs.

How the Problem Was Attacked

When it was determined that the various types of mechanical and soldered joints had failed to adequately provide what was wanted in the way of more efficient circuits, various other methods were attempted.

Fig. 1 Damaged cable is placed in mold for splicing. Cable ends are prepared and clamped in graphite crucible

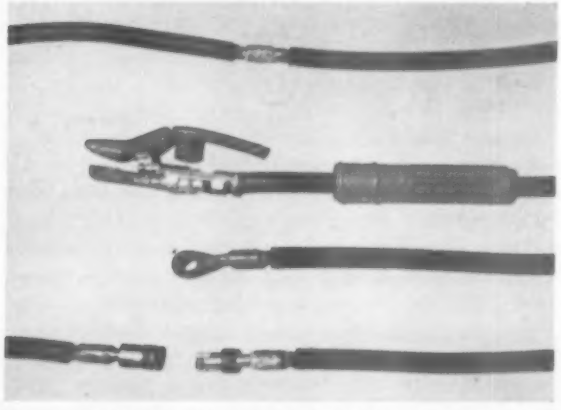


Fig. 2 Finished welds on cable, holder, lug and quick connectors

The first of these using silver solder instead of soft solder was eliminated because of excessive cost. Though the joint was much more efficient, the price was several times that of soft solder, and did not justify the result. There still remained the problems of excessive damage and burning of cable insulation during installation—especially on lugs, etc., and the need to properly clean the flux to avoid loss of conductivity. Obviously this was expensive.

Another method, tried and finally adopted as standard practice, was thermit welding (see Figs. 1 and 2). This method produced a satisfactory copper weld which is as efficient as the cable itself.

How One Problem Was Solved

With this all-copper-welded connection, melt-out, burn-out, loosening and corrosion are completely eliminated. Properly used, there is no damage to insulation.

Thermit welding equipment is inexpensive and no special skill is required to produce trouble-free joints. Materials are no more expensive than ordinary solder.

Yet other problems remained to be solved before the circuit maintenance program could reach peak efficiency.

Importance of Proper Insulation

Without proper insulation even the best connections cause trouble. Aside from the all important problem of current loss, there are safety problems to consider.

Most logical insulating material, tried first but found inadequate, was regular friction tape. This lacked durability under abrasion due to sliding and flexing. It was unable to withstand heat from the cable, was burned badly and frayed by spatter. In service, with cable getting greasy and oily, tape would not stay in place.

Even more expensive insulating tapes were tried, but these too were unsatisfactory for the same reasons. Actually with 400–500 amp going through connections, slipped insulation, with bare strands arcing, represented a serious safety hazard. This caused the decision to eliminate use of tape of any kind.

Vulcanizing Proves Most Efficient

After various rubber sleeve arrangements were tried and discarded for a variety of reasons, it was decided to try neoprene vulcanized cable connections.

A series of tests were conducted and a vulcanizer was chosen. Naturally the size and extent of a company's maintenance problems must determine advisability of using such equipment. Several vulcanizing units, suitable for less demanding operation, are available at very low cost. Subsequent results—and savings—substantiated the writer's opinion of this type of equipment.

Vulcanizing is done easily and efficiently by maintenance personnel (see Fig. 3). Aluminum molds used in the vulcanizing process are furnished by the manufacturer at relatively low cost. For special applications new molds are easily made. Neoprene wrapping tape, actually less expensive than conventional tape when length of service is considered, is used in making the vulcanized splice.

The finished joint, using welded copper connections and vulcanized insulation, is as efficient and durable as the cable itself. Having excellent insulating qualities, the connection virtually eliminates safety problems. Its small profile makes it safe to drag the cable when necessary since the load is spread over both insulation and connection. Result of this procedure has been the ability to salvage and re-use about 96% of welding cable.

Example of Cost for Typical Cable Repair

Including a full copper splice and vulcanized insulation, but not including amortization of the vulcanizer, here is how joint costs are estimated:

Thermit welding material	$0.385
Mold cost	0.015
Vulcanizing material	0.09
Labor	0.51
Total	$1.00

The amortized vulcanizer cost is not listed since no repair has been necessary, and the small cost for electricity (about that of using an electric iron) is insignificant in most operations. Minor injuries to cable insulation, with no conductor damage, cost about 25 cents per repair.

Since 2/0 cable in 1000-ft reels costs about $0.50 per foot, and 3/0 about $0.60 per foot, it is obvious that this program, enabling the operation to reclaim 96% of cable formerly scrapped, results in considerable savings. Actually this saving alone amounts to about $900 per month.

Problems in Relation to Arc Welding Accessories

Because conductivity problems, overheating of cable and accessories, high maintenance costs, etc., were prevalent throughout all welding circuits, it was necessary also to apply the same corrective measures to accessories (see Fig. 4). Thus holders, cable connectors, lugs and grounds were carefully examined and efficiency—or lack of it—analyzed.

Lugs

Starting with cable connections at machines, it was decided to use special lugs with studs suitable for the same type of welded copper connections as used to join the cable. These studs, though slightly more expensive than conventional solder or crimped types, proved so much more efficient and long lasting that the very small additional cost is justified.

Quick Connectors

Believing very strongly in the use of electrode holder leads, or "whips," the writer next investigated the various available types of quick connectors. Though many of these had valuable features, one type proved most efficient. This was a locking-type connector adapted for use with the welded-type copper cable connection.

The use of "whips"—a short length of cable welded at one end to a quick connector and at the other to an electrode holder—has eliminated cost of operator's waiting time, maintenance man's time and overhead. They minimize operator fatigue by giving him a lighter, more flexible lead which is much easier to manipulate. By having spare "whips" available, these can quickly be put on the job in the event of an emergency or holder breakdown.

Insulators for the quick connectors are vulcanized in a special mold, the same equipment as used for cable. Both halves of the connector are thus insulated and permanently attached to the cable insulation. This method has resulted in complete elimination of arcing and former high maintenance costs of replacing cracked or broken fiber connectors. The connections and cable strands are protected and a good waterproof joint results.

This program reduced maintenance on quick connectors by approximately 65%.

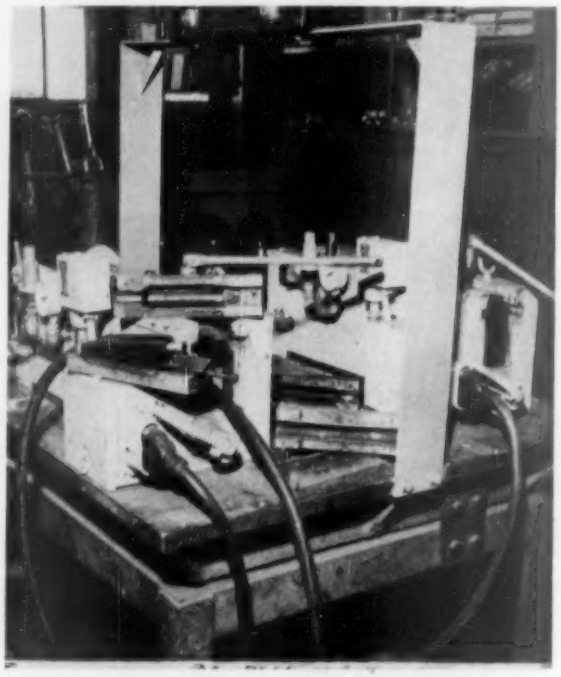


Fig. 3 Molds are inexpensive and last indefinitely. Durable insulation withstands flexing and prevents arcing

Grounds

On most operations, because of the size and type of weldments produced, conventional ground clamps are not practical. Instead, such grounds are fabricated from scrap plate approximately 5 x 7 x 1 in. thick. Normal procedure now is to first attach the cable to a cold-rolled rod by welding it with the thermit-type copper weld. The rod is then arc welded to the plate, a loop is tacked on, and this is pressed against the cable as an additional support to prevent flexing and possible broken strands. The result is a long lasting, 100% efficient electrical connection between the welding machine and weldment.

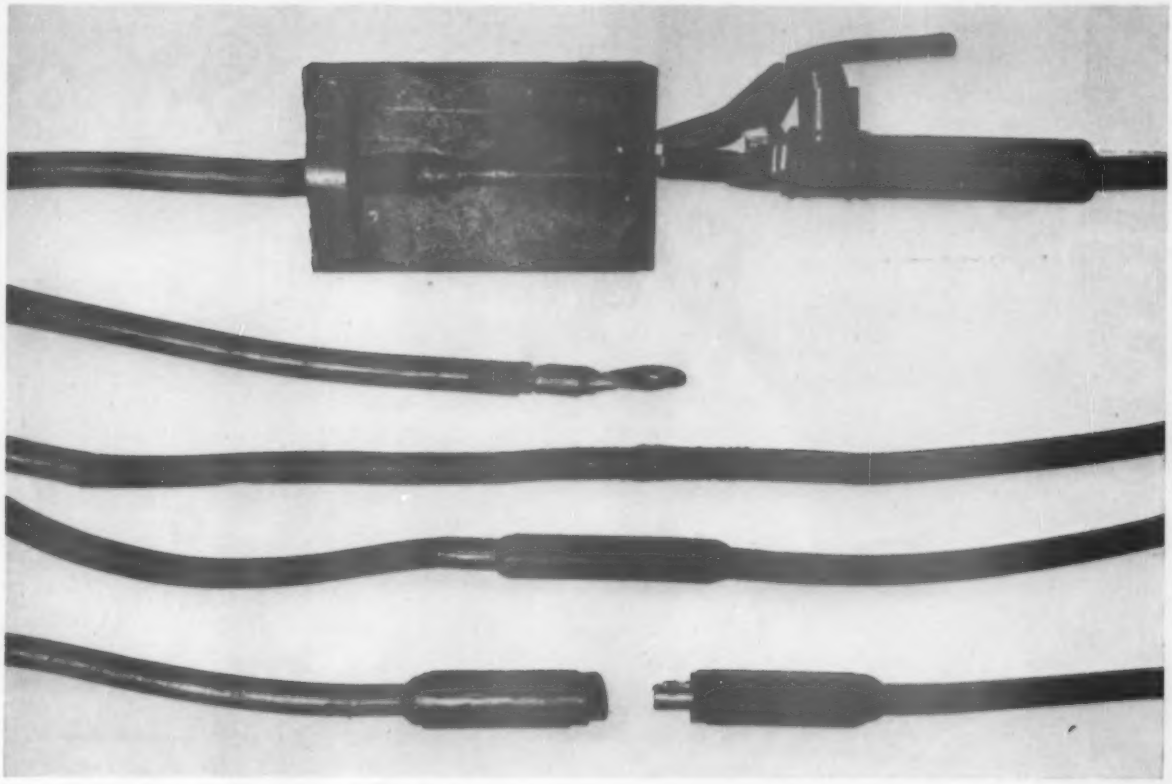


Fig. 4 Welded and jacketed; ready for production

In contrast to the former method of drilling and tapping holes for mechanical clamp-type lugs, this procedure has resulted in a 300% increase in the life of the plate, now fabricated at about two-thirds of previous cost.

Electrode Holders

Because of our success with 100% welded copper circuit connections, it was decided to follow the same procedure in the case of electrode holders.

Several types of electrode holders were tried and rejected for various reasons, primarily because they were not easily adaptable to the welded cable connections or could not be secured to the cable jacket. Electrode holders, with a solid copper connection, and a clamping device for securing it to the cable jacket as well, were finally selected. The holder is now standard equipment.

As a result of this standardization program, with the new type holders, costing about the same as conventional types in 300 and 500 amp sizes, over-all costs of holder maintenance have been drastically reduced and cable fraying at the holder has been practically eliminated.

The practice of using two holders alternately, to allow cooling, has been discontinued—and water buckets for cooling holders have been discarded.

Summary

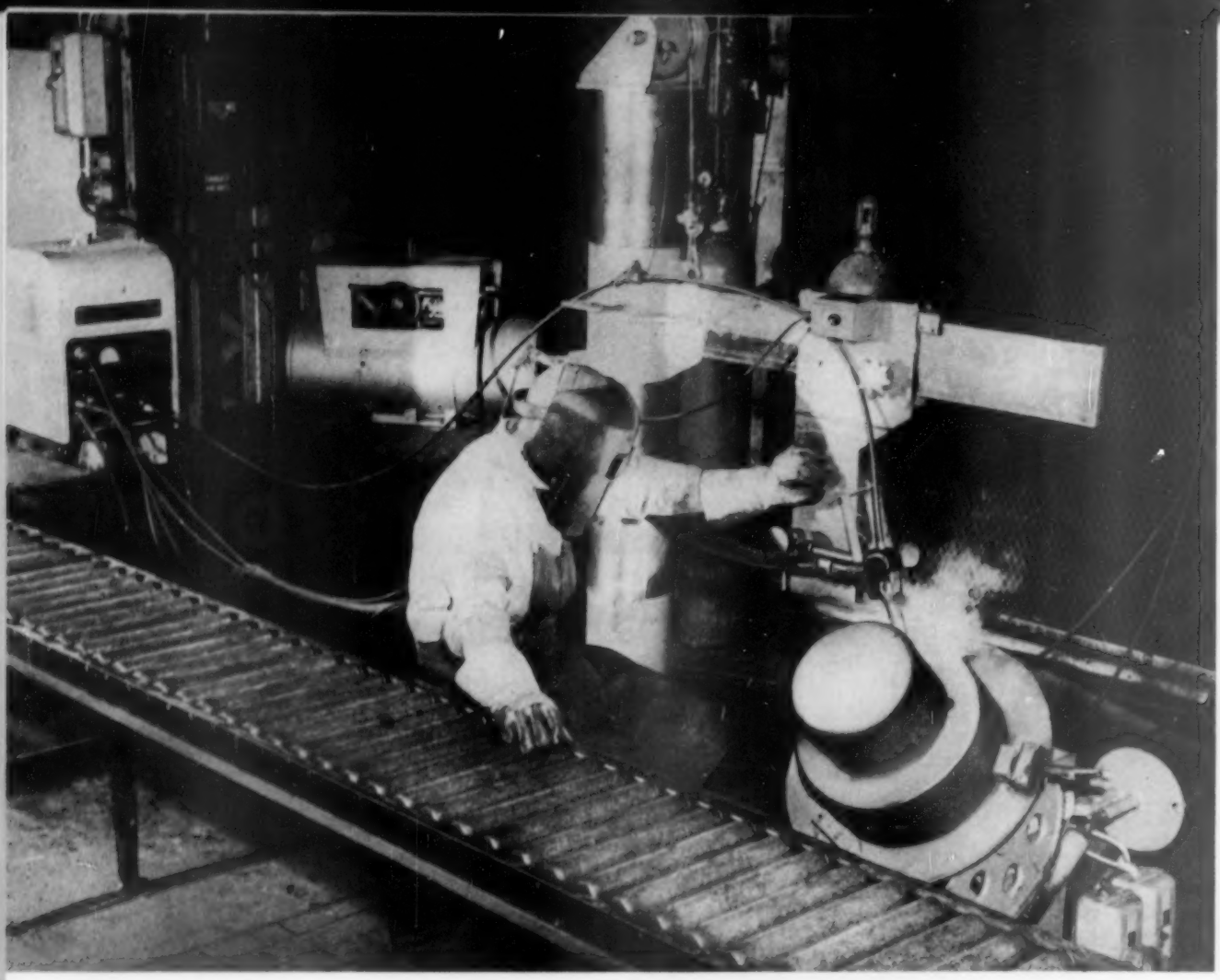
There are about 700 welding machines in regular operation in our Peoria plant. Each machine requires from 60 to 250 ft of cable. About 60 ft is most common with half on the electrode side, half on the ground side.

All welding circuit repairs are made at a central maintenance shop rather than on the job. If an emergency arises, such as cut cable, part breakdown, etc., a spare (whip or entire lead) is furnished from the maintenance shop and the damaged item returned for repair. Most of these "whips" remain in service until cable life is completely gone.

It is neither economical nor efficient to send maintenance men on "fire alarm" calls to make repairs. They would be forced to stop working on their currently scheduled jobs. In addition, the production welding operator would be idle and additional overhead for down-time would add to maintenance costs. These costs turn into savings by the "spare" program.

Because the cost of equipment necessary to conduct a program of this kind is moderate, within the scope of most operations, it could easily be adapted by other shops.

The elimination of so many quality and cost problems is well worth the investment even for welding departments where considerably fewer welding machines are used. Considering the investment in circuits and equipment, many manufacturers' welding departments can profitably adopt most of the features of this program.



Typical application of consumable-electrode carbon-dioxide-shielded welding of mild steel

MOISTURE AND ITS EFFECTS IN CARBON DIOXIDE WELDING OF STEEL

For good welding practice, the moisture content in carbon dioxide should be kept as low as is practical

BY R. W. TUTHILL

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Presented at AWS 1955 Fall Meeting held in Philadelphia, Pa., Oct. 17–21.

Introduction

Some of the deadliest enemies of the welding arc are air and water. Air is bad for the welding arc since nitrogen is present and water has hydrogen in it. Both of these gases tend to cause bad weld porosity and brittleness. In metal-arc welding, one function of the flux coating on the electrode is to exclude air from the arc area and also to ionize the arc gap. The bad effect of moisture in the flux coating, in this type of welding, led to the development of low-hydrogen electrodes.

In economical gas-shielded welding of mild steel, the air is excluded from the weld puddle by the use of carbon dioxide gas. It seemed logical, then, that moisture

in this gas might also have a detrimental effect on the results of the weld in somewhat the same way that moisture in the flux coating has a bad effect in metal-arc welding.

This reasoning led to an investigation of the effects of moisture in carbon dioxide gas when used as a shield for the consumable-electrode welding process on mild steel. Before we discuss this moisture investigation in detail, however, some discussion of carbon dioxide itself is pertinent.

Nature of Carbon Dioxide

It is important for the potential user of carbon dioxide gas-shielded welding, to know something of the nature of this gas. Commercial cylinders of this gas for welding are different from inert gases. About 68% of the tank volume of a full tank is liquid carbon dioxide and the other 32% is compressed gas in a new tank of gas. Cylinders of inert gas are all gas with no liquid phase. When the carbon dioxide regulator-flowmeter is turned on, gas is drawn off from the top of the liquid at a rate which can be above the recovery rate of the tank, therefore, the gas above the liquid may be depleted unless two tanks are used in parallel for each arc (see Fig. 1). When the tank is first used, the pressure will be approximately 875 lb per sq. in. at 72° F and it will hold this pressure of 875 lb per sq. in. so long as there is any liquid changing to gas in the tank and the temperature of the tank does not change. As the tank is used, more and more of the volume in the tank is gas and less and less is liquid. When all of the liquid turns to gas, then the pressure will begin to drop and it will do this rather rapidly. The tank will hold the maximum pressure for almost the full useful life of the tank and, as soon as the pressure begins to drop sharply, the tank should be taken out of use.

Also, it may be necessary, under conditions of high flow, to use a special carbon dioxide flowmeter-regulator or supplementary heat to prevent the regulators from frosting up with moisture both inside and out (see Fig. 1). The expansion of gas through the regulator cools it. The internal parts of the regulator may become cooled below 32° F and, if so, then any moisture in the gas may deposit in the regulator as ice.

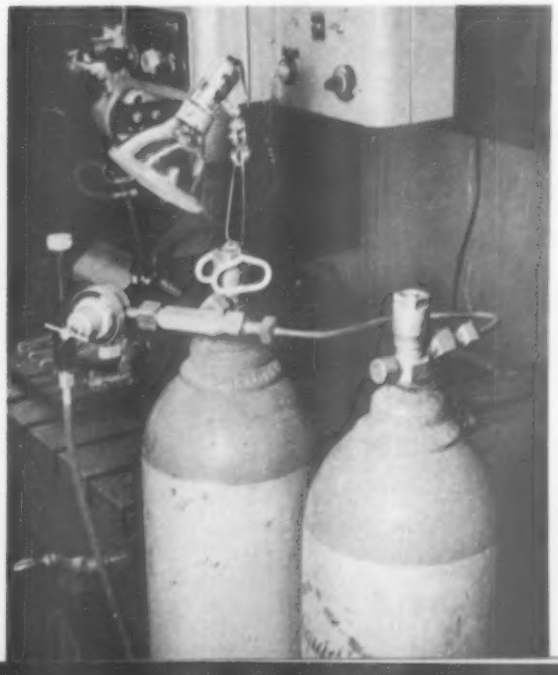
Effect of Moisture

The purity of carbon dioxide gas is of the same order of magnitude as inert gases—that is, above 99.5%. As with other gases, it is the type of impurity that is important. In carbon dioxide, one of the impurities can be water. Since early work exploring the use of CO_2 indicated erratic results, a program was undertaken to evaluate the effect of moisture in the new gas medium. The importance of moisture in manual flux-coated rod welding, with the introduction of low-hydrogen electrodes, indicated that some study should be made of the effect of moisture in gas-shielded welding.

One way to express the amount of moisture in the gas, is to measure the temperature of the gas when the moisture present in the gas will condense. This temperature is called "dew point"; the larger the quantity of moisture in the gas, the higher will be the dew point. A test installation was made to indicate and adjust the dew point (see Fig. 2). Measurements were made of moisture content in several bottles of commercial welding-grade carbon dioxide. The results of these tests are shown in Table 1. As can be seen, there was a wide variation between the high moisture high-dew point (−3° F) and low moisture low-dew point (−43° F). It appears that the problem of keeping the gas dry is one of insuring that dry tanks are always used.

Another method of utilizing carbon dioxide gas, available to fairly large users, is a bulk storage tank provided by the supplier of carbon dioxide gas and this tank is kept charged with liquid carbon dioxide. Gas

Fig. 1 Parallel tanks with heater



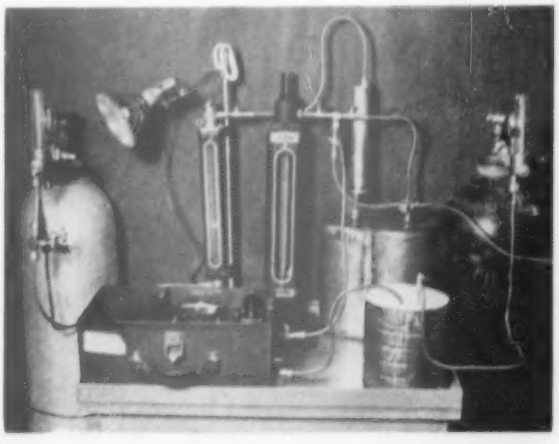


Fig. 2 Dew point indicating and controlling set-up

Table 1—Dew Point Measurements of Commercial Carbon Dioxide Cylinders

Brand A, °F	*Brand B, ° F*
−18	−33
−17	− 3
−16	−19
− 4	−43
−20	−17
−18	− 3
−28	−38
−26	− 6
−28	−17

Table 2—Chemical Composition of Electrode Used for Moisture Evaluation

Element	*Composition, %*
Carbon	0.09
Manganese	0.88
Silicon	0.36
Aluminum	0.01
Phosphorus	0.015
Sulfur	0.025

Table 3—Mechanical Properties of Weld Deposited Metal Vs. Dew Point Using Carbon Dioxide Gas

Dew point, ° F	*Yield strength, psi*	*Ultimate strength, psi*	*Elongation, % in 2 in.*	*Hardness Rockwell B*
+90	..	88,200	11	88–91
+81	65,250	81,411	15	85–87
+50	67,700	82,250	16	88–89
+26	71,600	84,000	11	86–87
+11	66,350	83,000	12	83–84
0	66,000	80,500	18	86–88
−18	64,400	78,500	22	83–85
−26	66,500	82,500	20	87–89
−33	67,400	82,500	20	86–87
−43	66,200	81,800	24	85–86

is supplied to this tank regularly by refilling the tank from a tank truck with liquid carbon dioxide being pumped into the tank. This method of obtaining carbon dioxide gas is very desirable for two reasons. First, the carbon dioxide is more economical when purchased in this bulk form and, second, gas of lowest moisture content is obtainable in this way.

Another method of supplying carbon dioxide gas is available to the user. This consists of filling a tank with blocks of solid carbon dioxide (dry ice), sealing this container, and allowing the gas to form a saturated liquid. This method has been used but it appears quite probable that this method, although economical, will produce considerable amounts of moisture in the system with dew points very high. The main source of moisture with this arrangement comes from the condensation of moisture in the air, on the blocks of carbon dioxide, during the charging operation.

When using bulk carbon dioxide systems, it is even more important that adequate pressure regulating equipment be used to insure that the gases would not be cooled below 32° F during the expansion process and, so, considerable care should be used in selecting proper flowmeter equipment. A flowmeter, adequate for one arc using gas from a tank, might not be adequate for a multiple-arc installation.

A test installation (Fig. 2) was set up in the laboratory so that moisture could be added to dry carbon dioxide gas to produce a shielding gas having varying dew points. By using the tank with the lowest moisture content, it was possible, by bubbling a portion of the gas through water, to adjust the dew point from −43° F to +90° F.

The electrodes used in these welding tests were $^1/_{16}$-in. diam of a composition shown in Table 2. This electrode was chosen since it proved to be satisfactory in previous tests comparing available electrodes.[1]

With the dew point varied over the whole range, all weld metal test specimens were prepared. An examination of the results shown in Table 3 indicates some very important points. First of all, high moisture content did not materially affect yield strength, hardness, or ultimate strength. It did affect percent elongation. Above −20° F dew point, the elongation dropped and readings became erratic and not easily duplicated. Although the change in elongation was definite, there was a great deal of abnormality in the specimens at the high moisture points. X-rays of all weld metal specimens did not show wide variation in porosity but porosity and cold shuts did show up in the pulled specimens.

Exographs of welds made with varying amounts of moisture did not reveal any significant increase in porosity with increase in dew point. All welds examined would normally be considered acceptable in this respect.

Spatter did increase with the addition of moisture to the gas. Figure 3, a radiograph, shows the increase in spatter typical of the higher dew point gas. It appears from these tests, that an effort should be made to keep the dew point at −20° F or below. The test, made on commercial grade CO_2, Table 1, indicated that not all of these tanks would meet this requirement, although they do not appear to be very far from the desired value.

Another effect noted in this investigation is shown in Fig. 4. This is a hole right into the weld, visible from the top surface. This was on a lap joint on $^5/_{16}$-in. thick plate, welded with carbon dioxide on a production part. The cause of the hole is not definitely known. However, in our investigation on all weld metal specimens, we observed these surface holes after we cooled the plates between passes by dipping in water. The second pass showed these holes. This was considered significant and the practice of cooling with water was discontinued and the holes were not again observed. This trouble may develop in production applications since it is possible that high moisture concentrations may accumulate in the regulator-flowmeter by freezing (even though the gas being used has a low dew point). If higher flows are used, then the regulator can pass without cooling the gas below 32° F. The resultant slugs of ice may come free from the regulator and enter the weld puddle. This could cause such holes to appear if water is the cause. The holes were not noted in our work if the plates were kept dry during cooling.

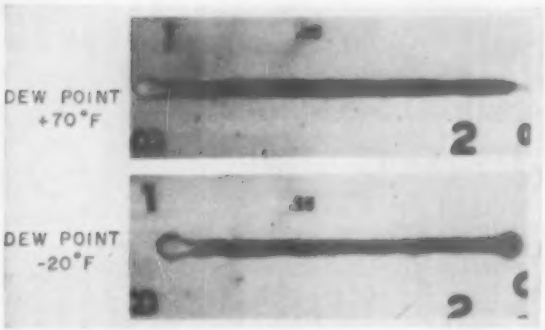


Fig. 3 Radiograph showing difference in spatter with high dew point

The lower the moisture content of the gas, the less chance of water freezing in the regulator.

Application

Because of obvious economies, (carbon dioxide costs but a fraction of one cent per cu ft) the future of gas-shielded mild steel welding depends upon our ability to use this gas.

Certain techniques are required to apply this gas that are slightly different than those techniques needed for inert gases. For one thing, a very short arc is necessary and the arc length must be held constant because this controls spatter to a great extent. High wire feed speeds must be used to give as high current densities as possible.

We mentioned constant arc length. Why do we desire constant arc length and not constant arc voltage? Consider the welding operator in manual metal arc welding, he holds a constant arc length. He does not concern himself with voltage since he knows from experience that, if he holds arc length constant, he will control undercut, penetration, spatter and the quality of the weld. This new gas-shielded method of welding is no different than metal arc in this respect: constant arc length is desirable, even on automatic equipment. In order to get constant arc length in this type of welding, it is imperative that a welding generator be used which has a rising volt-ampere curve.[2-4]

Since the arc characteristics themselves, in this type of welding, are rising—that is, an increase in current requires an increase in voltage for constant arc length—any constant arc length machine will also be a constant voltage machine so long as the wire feed speed is not changed. If the wire feed speed is increased, this requires an increase in current and a constant arc length machine will automatically increase the voltage required across the arc to hold this constant arc length. However, a constant arc voltage machine, although it will hold a constant arc length for any specific setting of wire feed speed, requires that the machine be reset if the wire feed speed is changed, in order to hold a constant arc length.

The results of these tests indicate that moisture in carbon dioxide has an adverse effect on the ductility of the weld metal. However, the yield and ultimate strength appears to be unaffected by moisture in the gas. Another factor of importance is the increase in spatter which can be kept to a minimum by using dry gas.

These tests also indicated the importance of not only using dry gas but also of the precautions that need to be taken to insure adequate flow of gas with the use of two tanks of gas per arc and correct flowmeter regulators.

Conclusion

Future study may indicate that other impurities in this gas may have an effect on the weld metal. It appears, however, that for good welding practice, the moisture content in this new welding medium should be kept as low as is practical—at least −20° F dew point or lower.

References

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2. Tuthill, R. W., "New Techniques in Inert-Gas-Shielded Metal-Arc Welding," THE WELDING JOURNAL, **34** (2), 137–141 (1955).
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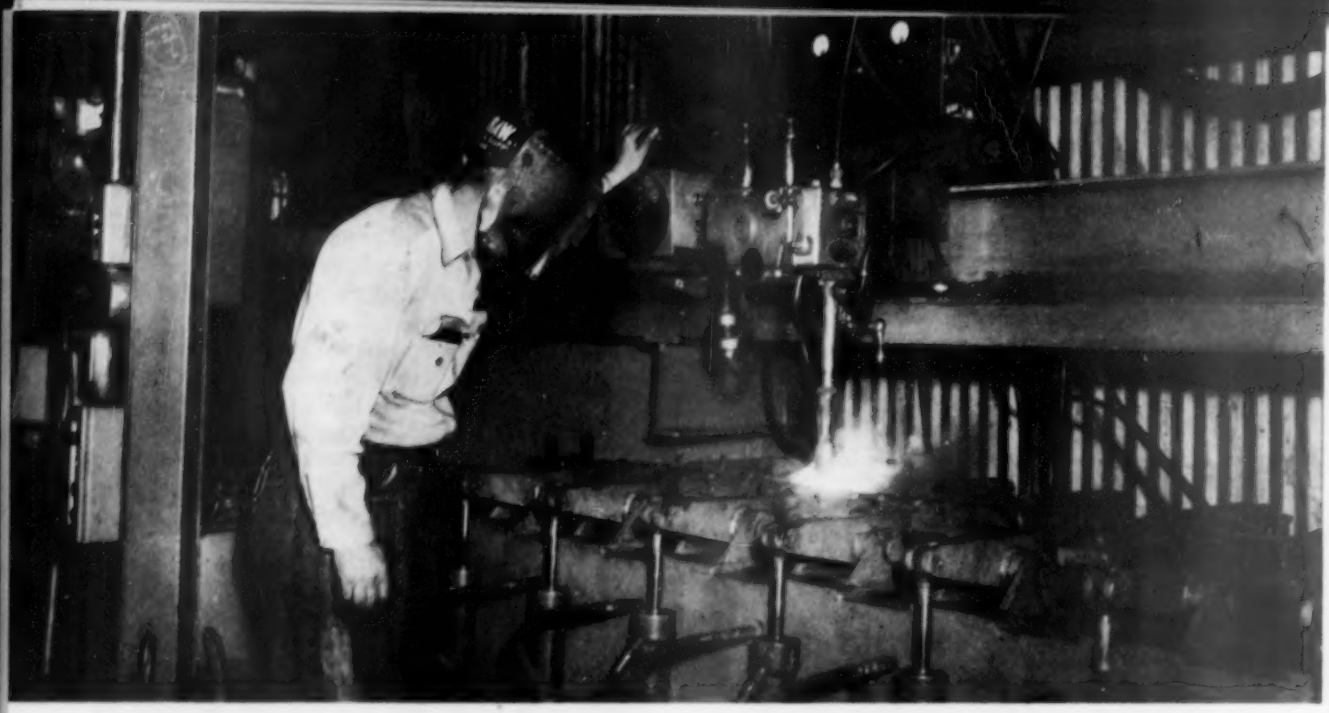
Fig. 4 Hole in air-conditioning compressor



Welding 4130 steel automatically

GAS-SHIELDED CONSUMABLE-ELECTRODE WELDING OF 4130 STEEL

Standard AISI low-alloy electrode analyses with controlled phosphorus and sulfur contents found to provide hardenability characteristics in the weld metal similar to those of low-alloy base metal

BY C. R. SIBLEY

Introduction

To weld the low-alloy high-tensile strength steels, such as AISI 4130, 4140 and 4340, suitable filler metals must be developed which will respond to the heat treatment that is used to obtain optimum plate properties. The heat-treated weld should produce a joint efficiency of 100% and should be crack free, sound and free of unfused areas. It is also highly desirable to have a filler metal that can be deposited without preheating the plate material.

In shielded metal-arc welding, the prevention of underbead cracking or weld-metal embrittlement that are caused by hydrogen evolved from the coating often requires a preheating or postheating treatment. Furthermore, it has been shown by Smith and Rinehart[1] that weld metal which has been deposited by covered electrodes and has the same chemical composition as the low-alloy plate material does not necessarily duplicate the mechanical properties and heat-treatment response of the plate. To obtain weld metal with properties matching those of the plate, the electrode analysis must be modified by lowering the carbon content and adjusting the alloy additions.

A complete absence of hydrogen in the arc atmosphere of the gas-shielded consumable-electrode process permits the deposition of crack-free welds in low-alloy plates of 0.40% carbon without preheating. In addition, standard AISI compositions with carbon contents equivalent to that of the plate can be employed as electrodes. Good element transfer across the arc[2] insures proper heat-treatment response from gas-shielded AISI-type electrode deposits. Excellent weldability has been obtained in 1/4-in. plate material under conditions of

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severe restraint in laboratory tests with electrodes containing 0.20 to 0.40% carbon with sulfur and phosphorus in the range of 0.010 to 0.020%.[3] These results indicate that the low-alloy steel electrodes used with the gas-shielded consumable-electrode process deposits weld metal with negligible cracking tendency.

This report concerns the results obtained in weld metal tests and mechanical tests from gas-shielded deposits made with several commercial and experimental high-strength consumable electrodes.

Materials

Equipment: Both manual and semiautomatic inert-gas consumable-electrode equipment of standard design was used for the welding tests. In addition, the following equipment was used:

Rotating-type welding generator, welding transformer, 75 open circuit volts.

Gas: Cylindered argon, argon + oxygen, and carbon dioxide.

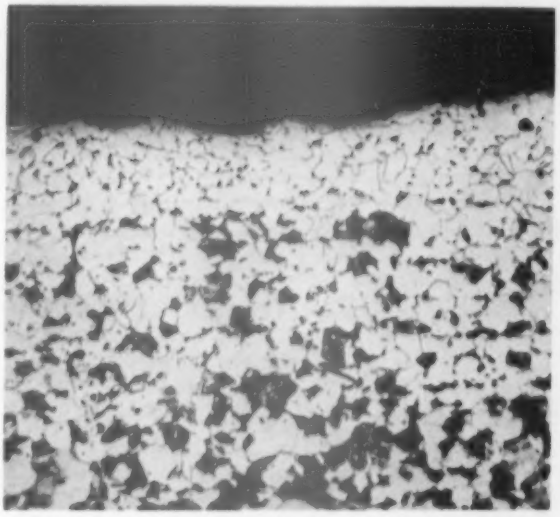
Plate: The plate materials were received in the normalized condition and cut into welding coupons with an oxy-acetylene flame. Welding was performed on the untreated flame-cut edge. Various heats of AISI 4130 and one heat of AISI 4340 were used. Figure 1 illustrates typical plate microstructures.

Electrodes: The seven electrodes which were employed consisted of standard or modified AISI compositions and experimental compositions. Some contain boron, others do not; all contain low phosphorus and sulfur. The composition of each electrode is listed in Table 1.

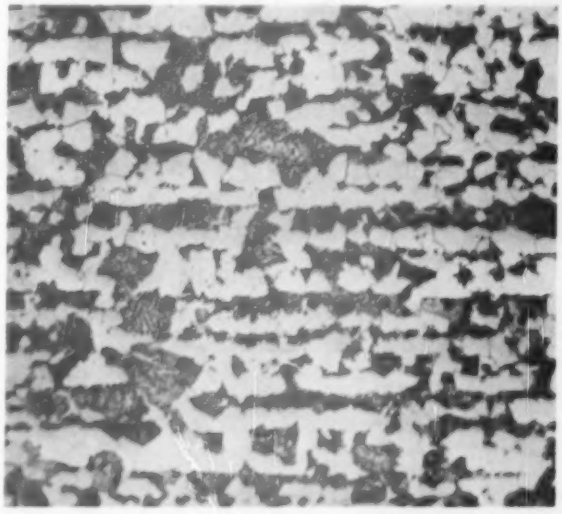
Procedure

Each electrode was evaluated by deposition of bead welds and single-vee groove deposits. Occasionally some additional testing was conducted on electrodes giving superior performance. The bead-weld tests offered a ready means of determining optimum operating conditions for each electrode as well as permitting porosity and cracking studies of the deposits. A single-vee butt-weld deposit was made to supply test specimens for heat treatment and subsequent mechanical testing. Reduced-section transverse tensile specimens and face-bend specimens were used as standard tests to determine electrode performance.

The heat treatments used were designed to obtain optimum plate properties since the intent was to determine if the weld deposit matched plate properties. The austenitizing temperature and quench media were



Structure at plate surface showing decarburization resulting from normalizing heat-treatment.



Structure within the plate illustrating pearlite-ferrite banded network.

X250 Nital Etch

Fig. 1 Microstructure of AISI 4130 $^1/_2$-in. plate

Table 1—List of Electrode Compositions

Designation	Size, in.	Composition, % C	Mn	P	S	Si	Ni	Cr	Mo	V	B
AISI 4320	$^1/_{16}$	0.17	0.45	0.020	0.020	0.20	1.65	0.40	0.20	—	—
		0.22	0.67	Max	Max	0.35	2.00	0.60	0.30		
AISI 6130	$^1/_{16}$	0.29	0.84	0.018	0.018	0.32	—	1.13	0.11	0.29	—
AISI 80B20	$^1/_{16}$	0.19	0.68	0.011	0.024	0.24	0.62	0.27	0.10	—	0.002
Experimental heat No. 406	$^1/_{16}$	0.32	0.88	0.011	0.014	0.71	0.82	0.40	0.12	—	0.0038
Experimental heat No. 433	$^1/_{16}$	0.27	1.01	0.014	0.011	0.85	0.85	0.38	0.11	—	0.0065
Modified AISI 6130	$^1/_{16}$	0.28	0.78	0.017	0.005	0.28	0.06	0.99	—	0.15	—
HT*	$^1/_{16}$	0.25	1.53	0.021	0.011	1.95	2.05	0.17	0.30	0.05	—

* Author's designation for a proprietary electrode, available commercially.

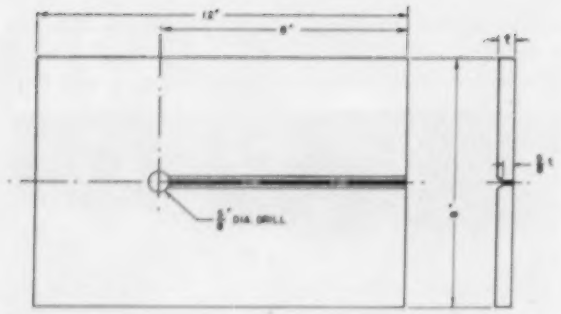


Fig. 2 *Crack susceptibility specimen*

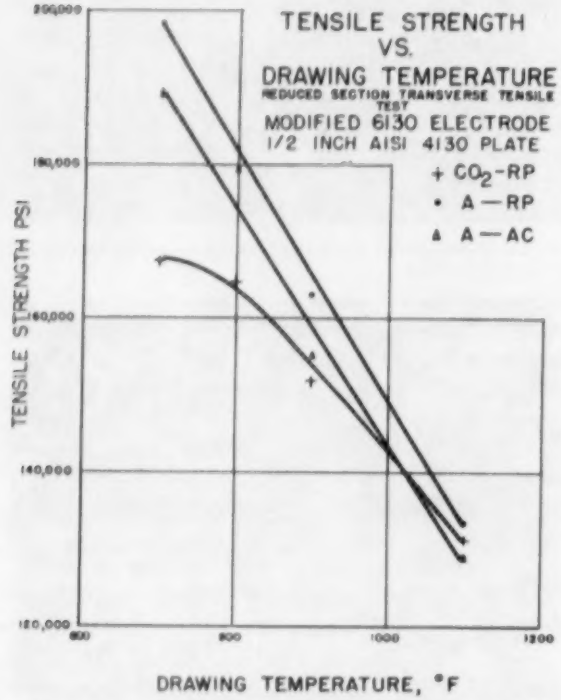


Fig. 3 *Transverse tensile properties of AISI 6130 deposits in AISI 4130 plate*

adjusted according to carbon content and plate hardenability. Water quenched specimens were subjected to a tempering treatment prior to testing, whereas oil quenched specimens were tested in both the as-quenched and quenched and tempered conditions.

Other test methods consisted of hardness tests, impact tests, hardenability tests and crack susceptibility tests.

Hardness data were obtained for both the plate material and the weld deposit to compare the hardness values after quenching and tempering. Impact testing of Charpy-type specimens machined from a weld deposit was conducted over a range of temperature. Standard end-quench hardenability data were obtained from 1-in. rounds machined from weld metal. A crack susceptibility specimen, Fig. 2, was made from $^1/_2$-in. AISI 4130 plate which was water quenched to a hardness of R_c 50. A single-pass weld was made starting at the plate edge and proceeding along the slot to the hole. Magnetic particle and radiographic inspection of a completed weld at various time intervals within a two-week period determined whether cracks initiated and if resident cracks propagated.

Both manual and mechanized welding techniques employing standard equipment and a $^1/_{16}$-in. electrode were used. Argon or argon plus oxygen shielded the majority of the deposits. Carbon-dioxide shielding was used for comparison with argon shielding to a limited extent. Reverse-polarity direct-current (RPDC) power was the standard welding power source. An emissive agent coated electrode[4, 5] permitted the use of 75 open-circuit voltage alternating-current power for comparison with direct-current power in mechanical property testing and electric arc blow studies. Joint designs were made with the oxy-acetylene cutting process except in the case of the crack susceptibility specimen which was friction cut and machined. Atmospheric conditions of preheat and interpass temperature were used throughout all the welding tests.

Results

Examination of bead welds deposited on 4130 plate revealed no evidence of underbead or weld metal cracking with any of the electrode materials investigated. Argon plus 1 or 2% oxygen shielding and reverse-polarity direct-current power were the standards for this test. A welding current of 300–350 amp produced a characteristic spray transfer of metal droplets across the arc with argon shielding. Carbon-dioxide shielding produces a large drop-type transfer with considerable spatter.

The transverse tensile properties obtained from heat-treated butt welds made with each of the seven electrodes are shown in Table 2. Argon plus oxygen and reverse-polarity direct current were used throughout these tests. Two electrodes, the proprietary electrode herein designated as HT and the AISI 6130 electrode, exhibit heat-treated tensile properties which match those of AISI 4130 plate. Weld metal fractures occurred in the HT deposits at all drawing temperatures, whereas in the AISI 6130 deposits the fracture location moved from weld metal to plate when the temperature of drawing reached about 850° F. The joint ductility of the AISI 6130 deposits rose steadily with tempering, while the HT deposits gave consistently low values of elongation.

Impact test data obtained from Charpy-type specimens containing an Izod notch did not indicate that the low ductility of the HT deposits caused low-temperature embrittlement, since the same impact strength was obtained at testing temperatures of 72 and −40° F, as shown in Table 3. An 850° F temper improved the impact values obtained at 72° F, but did not alter the −40° F values.

The boron-treated electrodes, 80B20, experimental 406 and experimental 433, failed to match the heat-treated tensile properties of AISI 4130 plate even when

Table 2—Transverse Tensile Properties of Welded Joints After Heat Treatment (Argon Shielding DCRP)

Electrode	*Plate*	*Austenitize temp., ° F.*	*Quench media*	*Draw temp., ° F.*	*Tensile strength, psi*	*Elongation %, 2 in., GL*
AISI 4320	1/4 in., 4340	1550	Oil	None	210,000	7.0
AISI 6130	1/2 in., 4130	1575	Oil	None	182,500	5.0
Modified AISI 6130	1/2 in., 4130	1600	Water	700	200,000	6.0
HT	3/4 in., 4130	1600	Water	600	214,650	7.5
AISI 80B20	1/2 in., 4130	1625	Water	600	126,600	5.0
Experimental heat No. 406	1/2 in., 4130	1575	Water	800	177,000	4.0
Experimental heat No. 433	1/2 in., 4130	1575	Water	800	165,600	2.5

Table 3—Mechanical Properties of HT Electrode Deposits

Heat treatment	*Fracture location*	*Tensile strength, psi*	*Elongation, % in 2 in.*	*Vee notch impact, ft-lb; room temp., −40°*	
1600° F, WQ; 600° F draw	In weld	214,650	7.5	11.8	11.5
1600° F, WQ; 750° F draw	In weld	188,900	5.5	11.7	12.1
1600° F, WQ; 850° F draw	In weld	175,800	6.0	24.8	10

Welding conditions

Plate 3/4 in., 4130
Wire 1/16 in., HT

Current 290/310 amp
Voltage 27/28.5 v
Shield gas A + O_2 @ 35 cfh
Welding speed 1.61 ipm

Joint

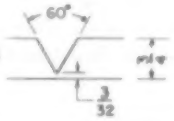


Table 4—Analyses of AISI 6130 Deposits Shielded with Argon + 1% O_2 and Carbon Dioxide

	Composition, %							
	C	*S*	*Si*	*Mn*	*P*	*Ni*	*Cr*	*V*
Argon + 1% O_2	0.236	0.008	0.22	0.67	0.016	0.06	0.89	0.08
Carbon dioxide	0.155	0.005	0.12	0.47	0.016	0.08	0.82	0.08

the carbon content was equivalent.

The AISI 4320 electrode is a good match for AISI 4340 sheet material where the admixture of carbon from the sheet produces a strengthening effect. Failure occurred in the sheet during transverse tensile tests indicating an overmatching weld deposit.

Based on the results obtained in the transverse tensile tests, the modified AISI 6130 electrode was considered the best match for the welding of AISI 4130 steel plate material. This electrode was, therefore, used as an example of a suitable filler metal for the welding of 4130 steel and further testing sought to determine its ability to match both tensile and hardenability properties of 4130 steel.

The tensile strength obtained in reduced-section transverse specimens welded with the modified AISI 6130 electrode in 1/2-in. AISI 4130 plate after drawing at various temperatures is shown for three conditions of welding in Fig. 3. This figure shows little difference in argon deposits made with direct-current and alternating-current power; however, the properties of a carbon-dioxide shielded deposit show a decided decrease in the maximum tensile strength which was caused by a loss in weld metal carbon content. The analyses of AISI 6130 weld deposits made with carbon dioxide and argon shielding are shown in Table 4.

The tensile and chemical results shown here for multilayer carbon-dioxide-shielded deposits do not reflect the deposit analyses or properties obtainable in other type deposits. For example, a carbon-dioxide-shielded deposit in sheet material might develop full strength on heat treatment through dilution effects as in the case of mild steel covered electrode deposits.

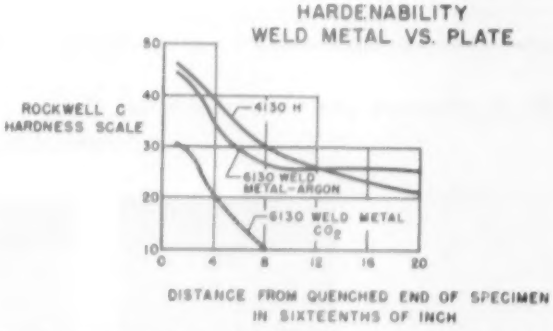


Fig. 4 Hardenability of AISI 6130 weld metal deposit; argon vs. carbon dioxide

Jominy end-quench hardness data obtained from 1-in. round weld metal specimens machined from argon and carbon-dioxide-shielded deposits are compared to the hardenability curve of 4130 H steel in Fig. 4. These data emphasize the effect of element burn-out on the hardenability and maximum hardness. The hardenability curve of the argon-shielded deposit exhibits a

lower maximum hardness than 4130 H steel, but the over-all curve indicates a good hardenability match.

The angle of bend obtained in standard $^3/_8$-in. face-bend specimens as a function of drawing temperature, after a water quench from 1650° F, is shown in Fig. 5. Argon shielding, with two types of power supply (dc and ac) is compared to carbon-dioxide shielding with d-c power. There is little difference in the behavior of the argon-shielded deposits with either type power. The curves show a general increase in the angle of bend from 10 to about 30 deg as the drawing temperature increases. Carbon-dioxide shielding causes an increase in the angle of bend as would be expected from the results of the tensile tests. The elongation values obtained in the transverse tensile specimens do not show the similar behavior demonstrated by argon shielding in the bend-test specimens. Figure 6 illustrates the elongation measured in a 2-in. gage length as a function of the tensile strength. Considering the case of the argon-shielded deposits, it is evident that in the tensile strength range above 180,000 psi, the performance of alternating-current and direct-current deposits is simi-

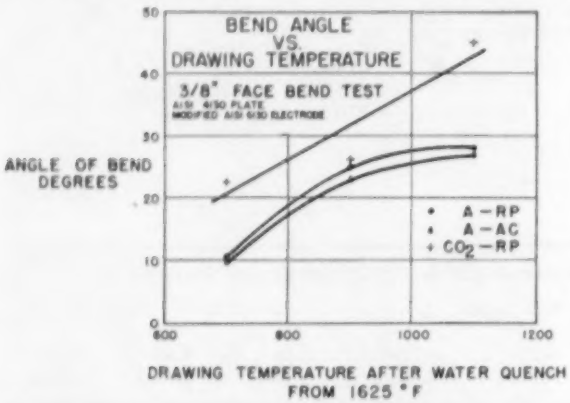


Fig. 5 Bend test data of AISI 6130 deposits in 4130 plate

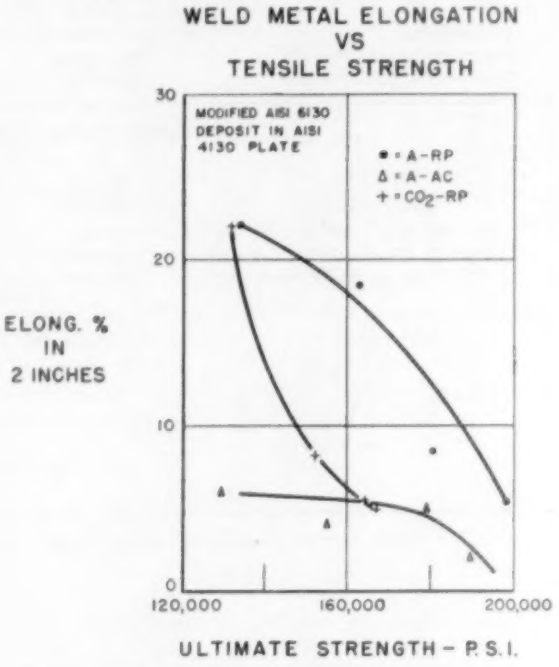
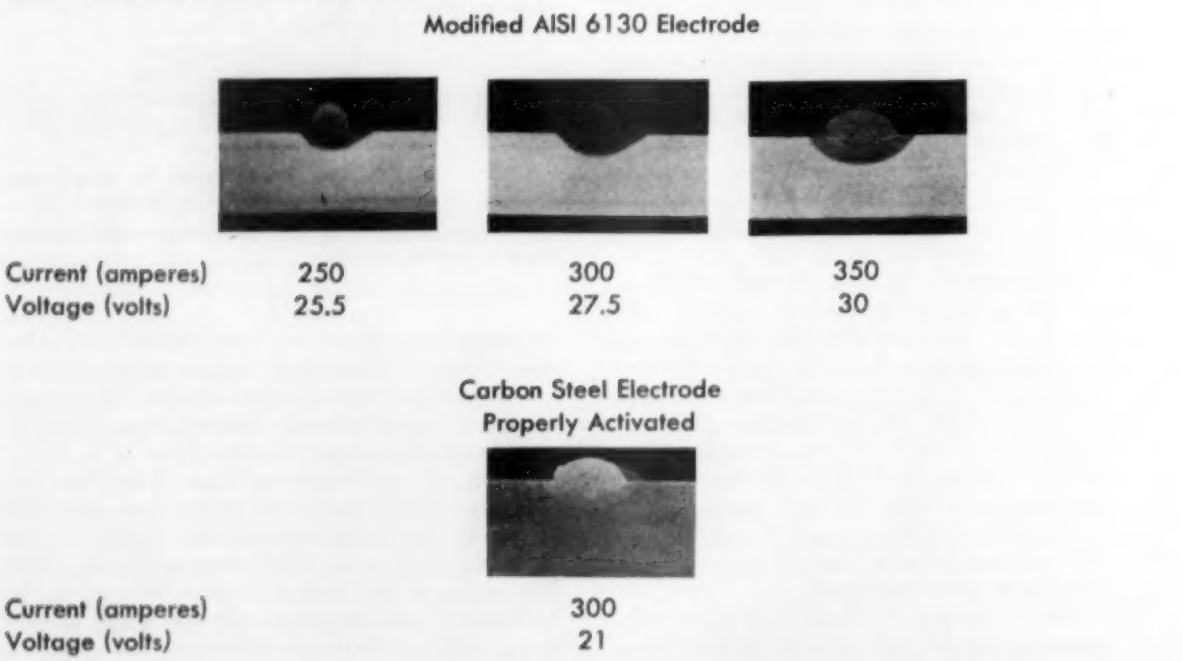


Fig. 6 AISI 6130 weld metal elongation

Fig. 7 Alternating current bead weld shapes



lar. Below a tensile strength of 180,000 psi, failure occurred in the plate material for direct-current deposits, while the weld failed in the alternating-current deposits. This change in the location of failure reflects the poorer interbead bonding characteristics of the alternating-current deposit.

A solution-coated electrode which is properly treated forms rather deep penetration and relatively flat bead weld contours when a-c power is used. The solution-coated electrode used herein undoubtedly was improperly activated for a-c operation. Figure 7 illustrates the difference in shape and penetration of alternating-current bead welds when the subject electrode was operated at various currents. Since the a-c deposits used for tensile tests were made at 325 amp, one can readily appreciate from the bead weld shape shown in Fig. 7 that rather poor interbead bonding must have resulted. Included in this figure is a bead weld made with a different electrode which was properly activated, illustrating the change in bead shape and penetration between improper and proper activation.

A plot of weld metal hardness as a function of ultimate tensile strength is shown in Fig. 8 for the three conditions of welding. The hardness of the argon-shielded deposits are similar, but the carbon-dioxide shield caused a decided loss in maximum hardness due to the loss in carbon content.

The deposits made from electrodes containing boron consistently gave relatively low values of elongation in tensile tests at all drawing temperatures following either oil or water quenching. Table 5 summarizes the results obtained with boron-treated electrode deposits in tensile tests following various heat treatments. Failure always occurred in the weld with these deposits. Consideration was given to the possibility of temper-embrittlement occurring during heat treatment of boron deposits. To minimize the time-at-temperature the deposits were water quenched following tempering.

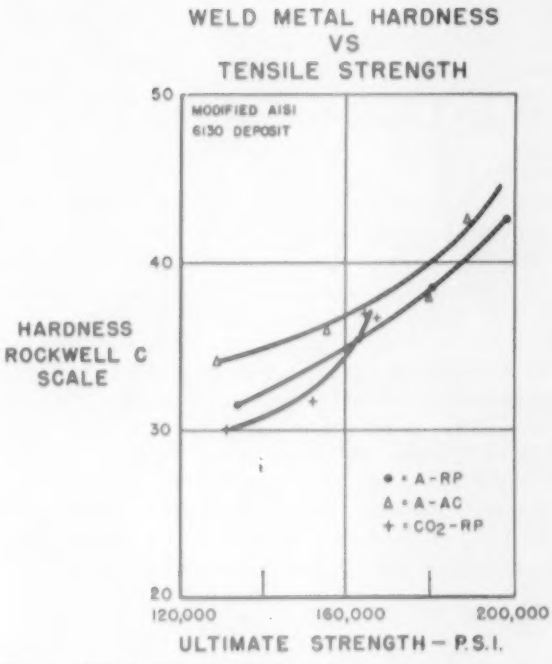


Fig. 8 AISI 6130 weld metal hardness

Comparison of the results obtained from specimens water quenched and air cooled after tempering indicated no change in ductility or location of fracture.

Oil quenching, in general, resulted in lower tensile

Table 5—Properties Obtained with Boron Electrodes (Single-Vee Butt Weld in $^1/_2$ inch 4130 Plate)

Electrode	*Size, in.*	*Heat treatment*	*Fracture location*	*Tensile strength, psi*	*Elongation, % in 2 in.*
80B20	$^1/_{16}$	As-welded	In weld	97,500	15
Welding cond.					
325 amp		1625° F, OQ	In weld	123,700	5.5
30 v		1625° F, OQ;	In weld	126,600	5.0
10 ipm travel		600° F draw, WQ			
3 passes		1625° F, OQ;	In weld	114,900	5.0
		800° F draw, ac			
Experimental heat No. 433	$^1/_{16}$	1575° F, WQ;	In weld	165,600	2.5
		800° F, draw, WQ			
Welding cond.					
325 amp		1575° F, WQ;	In weld	118,000	5.0
30 v		1100° F draw, WQ			
9 ipm travel		1575° F, OQ;	In weld	133,600	11.0
2 passes		800° F draw, WQ			
		1575° F, OQ;	In weld	111,200	11.5
		1100° F draw, WQ			
Experimental heat No. 406	$^1/_{16}$	1575° F, WQ;	In weld	177,000	4.0
		800° F draw, WQ			
Welding cond.					
320 amp		1575° F, WQ;	In weld	134,500	12.5
30 v		1100° F draw, WQ			
8.5 ipm travel		1575° F, OQ;	In weld	128,600	12.0
2 passes		800° F draw, WQ			
		1575° F, OQ;	In weld	109,100	9.5
		1100° F draw, WQ			

strength and higher elongation values than obtained with water quenching but the data lack complete consistency. When an 80B20 deposit was tested in the as-welded condition the resultant weld-metal elongation was quite high. These data indicate that the boron-containing electrodes used in this investigation do not develop sufficient strength and ductility to be considered suitable filler materials for welding low-alloy heat-treatable steels.

Whether or not boron is transferred across the arc was checked by chemical analysis of a multilayer deposit of 80B20 weld metal. The boron content of the electrode was reported as 0.002% and that of the weld metal deposit as 0.002%. A 1-in. round end-quench hardenability specimen was machined from this deposit. The resulting hardenability performance was inferior to normal 80B20 response. This loss of hardenability was caused by a loss in weld metal carbon content which seriously reduced the intensifying action of the boron. Argon plus oxygen and reversed-polarity direct current were used for this deposit.

Discussion

The mechanical test results obtained with electrodes of standard AISI composition, having low phosphorous and sulfur contents, indicate that such electrodes are suitable filler materials for inert-gas-shielded metal-arc welding of AISI low-alloy heat-treatable steels. In certain applications, such as the joining of sheet material, full-strength joints may be obtained with an electrode of leaner chemistry than the sheet due to the relatively high values of plate dilution. The welding of thicker sections employing multipass techniques requires that the weld deposit exhibit adequate strength and hardenability to match the material being welded when it is subjected to a certain heat treatment designed to develop optimum properties in the weldment. The electrode used in this instance must contain adequate alloying elements and carbon content to effect proper strength and hardenability without consideration of dilution effects during welding. To prevent weld-metal cracking, the phosphorous and sulfur contents in the electrode must be held to very low percentages. This requirement of low phosphorus and sulfur was affirmed in the restrained bead weld test shown in Fig. 2. No cracking was experienced in this specimen by deposits made with the modified AISI 6130 electrode, whereas a standard AISI 6130 electrode, not illustrated in Table 1, with considerably higher sulfur and phosphorus cracked the entire length. No attempt was made to determine a threshold value of sulfur or phosphorus which would define the limits of cracking. Such a value obtained in any laboratory test would not explain cracking in general because no individual test could completely define all areas of welding procedure and restraint. For this reason, the requirement of low phosphorus and sulfur is offered as a requisite to good weldability at any level of restraint.

Discussion of Magnetic Arc Blow

During the welding tests conducted for this investigation a decided decrease in electric arc blow was observed when alternating-current replaced direct-current power. Often the arc blow attending dc deposits was quite severe although the common joint type was a single-vee butt with steel or copper backing.

It is characteristic of the argon-shielded arc with a consumable-steel electrode operating at reversed-polarity direct current to form a definite pinch at the electrode end of the arc which, combined with electrical forces, propels a stream of small drops along the electrode axis to the weld pool. A force field about the electrode holds the arc in its axial position and gives a stiffening effect to the arc column. Under the influence of a magnetic field, the arc column moves in a direction predicted by the shifts in the force field. Electrical pinch, under conditions of arc blow, transfers the metal droplets of the arc column at skew angles to the electrode. Severe cases prevent transfer of the drops to the weld pool or extinguishes the arc. Alternating current generally reduces or eliminates arc blow due to the action of eddy currents in the plate.

Comparison of the mechanical property results obtained with d-c and a-c power indicate that there is little difference in behavior except for the values of elongation where weld metal failures caused the a-c deposits to be inferior.

A solution-coated electrode containing a minute amount of emissive agent is necessary to stabilize the a-c welding arc in argon. Such electrodes are not available commercially but the data obtained using a solution-coated electrode were included to point out the possibility of using a-c power from standard welding transformers with the inert-gas-shielded metal-arc process. The advantage of using alternating current in lessening magnetic arc blow may be of considerable importance in certain applications, especially where severe magnetic arc blow prohibits the use of direct current.

Summary

Although no current electrode specifications exist for the application of the inert-gas-shielded metal-arc process to the welding of low-alloy heat-treatable steels, it has been shown herein that this process has definite advantages in such an application. The ability to use filler materials with carbon contents equivalent to the plate being welded insures the attainment of equivalent strength in the weld deposit. Standard AISI low-alloy electrode analyses with controlled phosphorous and sulfur contents provide hardenability characteristics in the weld metal similar to those of low-alloy plate material. When carbon dioxide is substituted for argon as the shielding gas a considerable loss in carbon, silicon and manganese results which produces a weakened weld metal of low hardenability. Boron containing electrodes were found to be inferior to standard analyses electrodes.

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Low-hydrogen iron-powder electrodes being used on an excavator car body

PROPERTIES AND APPLICATIONS OF LOW-HYDROGEN IRON-POWDER ELECTRODES

Low-hydrogen electrodes with iron-powder additions to the coatings have been successfully designed for good quality and operation and are commercially available in both titania and lime-type coatings

BY D. C. SMITH, W. G. RINEHART AND D. C. HELTON

ABSTRACT. Two commercial groups of low-hydrogen electrodes having 30 and 50% iron powder in their coatings were tested along with three brands of conventional E7016 electrodes and results compared. Tables, charts and photographs show results obtained on efficiencies, burn-off and deposition rates, tensile and yield strengths, ductility, Charpy-Vee impacts, and horizontal-, vertical- and flat-position welding. The results show that the mechanical properties of the weld metal are equivalent to those of the conventional E7016 electrodes and that deposition rates increase in proportion to the amount of iron powder added to the coating.

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Introduction

Several years ago (1948) our laboratory developed an electrode with deep penetrating and arc cutting characteristics, these characteristics being obtained by

adding relatively large quantities of iron powder to a rutile cellulosic type of coating.

Within the past two years several new so-called "contact" or iron-powder electrodes based on the E6012- and E6020-type formulas with excellent deposition rates, mechanical properties, efficiencies and operator appeal have appeared on the market and have been received by the welding industry with marked success.

During the past year several low-hydrogen iron-powder electrodes have made their "debut" and are gaining in popularity each month. The AMERICAN WELDING SOCIETY has not as yet given these new low-hydrogen iron-powder electrodes a classification number.

While commercial low-hydrogen-type electrodes with large quantities of iron powder in their coatings are new in this country, they have been produced in Europe for several years with varying degrees of success and customer acceptance. The European low-hydrogen iron-powder electrodes have approximately 30% iron powder in their coatings but the operational characteristics such as speed of welding, efficiency, and ease of handling are not much different from our conventional low-hydrogen electrodes without iron powder in the coating.

The development of low-hydrogen iron-powder electrodes has lagged behind the earlier rutile types because of present lower market potential, lack of special processing equipment, time required for developing and testing satisfactory formulas, and the working out of production problems. The unique properties and general acceptance of the first iron-powder electrodes has set a standard for operational characteristics that the user wants and expects from the low-hydrogen type. We now feel that the development of the low-hydrogen iron-powder electrode has reached that stage where equal advantages are obtained over the conventional E7015 and E7016 as are obtained by the E6024 over the E6012 electrode.

American manufacturers are currently producing two types of low-hydrogen iron-powder electrodes, one with 30% iron powder similar to the above European type and the other with 50% iron powder in the coating. The popularity of these iron-powder electrodes has created an immediate desire for more information concerning their specific properties and possible applications and especially how they compare with our older conventional types.

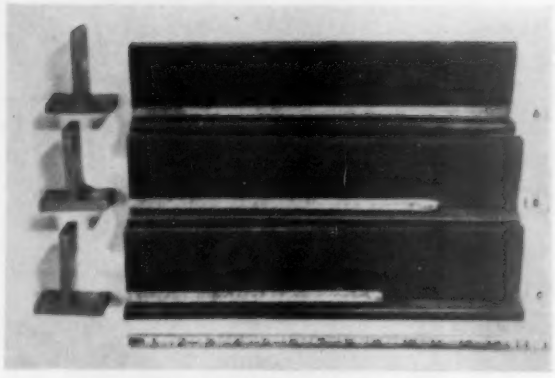

Fig. 1 Horizontal fillets ($^5/_{16}$-in.) made with $^3/_{16}$-in. electrodes. A, E7016 50% iron-powder modified; B, E7016 30% iron-powder modified; C, E7016

Hinkel,[1,2] Mathias,[3] and Howard[4] have reported on the welding characteristics, mechanical properties, and uses of the rutile and iron oxide type iron-powder electrodes. Hinkel classifies these iron-powder electrodes by comparing them with conventional electrodes, as for instance, E6014 is similar to E6013, E6024 is similar to E6012, and E6027 is similar to E6020 with iron powder added.

In this report we are comparing the new low-hydrogen iron-powder electrodes with the conventional E7016 types.

Preparation of Test Specimen

Plate Material—Mild steel conforming to ASTM designation A285 or A7 was used.

Tensile Specimens were prepared according to AWS-ASTM-A233-55T specification.

Efficiencies, Deposition and Burn-off Rates were made in the flat position on $^3/_4$- x 6- x 12-in. plate. The time was kept with a stop watch and the current and voltage measured with a recording meter and checked occasionally with a portable tong meter.

Charpy Impacts (Vee Notch)—The Charpy-Vee specimens were prepared and tested according to the ASTM-E23-47T procedure. The test specimen was taken

Table 1—Comparison of Coatings on the $^3/_{16}$-In. Electrodes Tested

Distinguishing constituents	*Conventional E7016*			*E7016 modified with 30% iron powder*		*E7016 modified with 50% iron powder*	
	*1**	*2*	*3*	*4*	*5*	*6*	*7*
$TiO_2 + ZrO_2$, %	27.0	28.0	28.0	6.0	5.0	12.0	17.0
CaO + MgO, %	25.0	27.0	26.0	30.0	28.0	8.0	11.0
Powdered iron, %	4.5	4.0	4.5	30.0	31.0	51.0	48.0
Ratio CaO/TiO_2	0.93	0.96	0.93	5.0	5.6	0.67	0.65
Moisture, %, as received	0.19	1.50	0.48	0.20	0.19	0.10	0.13
Coating, %	23.5	25.0	24.0	31.0	31.0	49.0	54.0
Optimum welding amperage in flat position	225	225	225	250	250	280	280
Maximum welding amperage in flat position	250	250	250	275	300	350	325

* Indicates electrode number.

Fig. 2 Flat position, single and double beads, made with $^{3}/_{16}$-in. electrodes. A, E7016 50% iron-powder modified; B, E7016 30% iron-powder modified; C, E7016

transversely to direction of welding from a single-V butt weld made on $^{1}/_{2}$-in. thick plate, 60-deg included angle, $^{1}/_{2}$-in. root opening, using $^{3}/_{16}$-in. size electrodes. The notch was cut in the center of the weld perpendicular to the direction of welding.

Coating Types

Table 1 gives the composition of coatings on the seven types and brands of electrodes used in this investigation. Only the constituents normally used in differentiating low-hydrogen coatings are included in the table, namely, titanium oxide (TiO_2 + ZrO_2), calcium oxide (CaO + MgO) and iron-powder additions. The ZrO_2 occurs in small amounts with the rutile or ilmenite ores generally used in the coatings, and since its reaction is similar to that of the TiO_2 it was combined in the table. Likewise, CaO and MgO were combined and are given in the second row of Table 1. The ratio of CaO to TiO_2 is given in the fourth row for comparison.

The definition generally used for titania- and lime-type coatings is as follows: Coatings containing less than 8% TiO_2 are rated as lime and those containing more than 16% TiO_2 as titania coatings. Those that fall in between 8 and 16% TiO_2 are called lime-titania types. According to this definition the coatings of the three conventional E7016 electrodes tested are all titania types, the 30% iron-powder group is lime type and the 50% iron-powder group is titania type. The percentage of the nonmetallic compounds in the iron-powder groups appears quite low compared to the conventional E7016 group but this is due to the large amounts of iron powder in the coatings. When calculated on the basis of the nonmetallic constituents only, the precentages would increase approximately 45 and 100%, respectively, for the two iron-powder groups.

The moisture content of the electrode coatings as received is given in the fifth row of Table 1, the percent coating in the sixth row, and the optimum and maximum welding currents as determined by our tests are given in the seventh and eighth rows, respectively.

Operational Characteristics

Iron-powder electrodes of all types have a very smooth, steady arc and with some types (rutile, E6024, and iron oxide, E6027) an operator could easily select a welding current too high for best welding quality.[3] The danger of using excessive welding current for best quality with the low-hydrogen iron-powder types is less likely because of their inherent property to use high currents advantageously. Current settings of 10 to 25% higher for the 30% iron-powder modification and 25 to 50% higher for the 50% iron-powder modification over the conventional E7016 are recommended. These higher currents improve weld-bead appearance, weld-metal deposition rate, and the quality of weld-metal deposit.

Table 2 gives the welding amperage range which we feel is best for the various types and sizes of electrodes used in this study.

(a) Horizontal- and Flat-Position Welding

In Fig. 1 horizontal fillet welds approximately $^{5}/_{16}$-in. size, using the optimum welding current given in Table 1 and d-c reverse polarity, show the appearance and length of beads made from burning 13 in. of the $^{5}/_{16}$-in. electrode from each of the three groups. The first inch was cut off to show the cross-sectional profile of each fillet. The greater current carrying capacity of the iron-powder type permits the use of 18-in. length electrodes in the $^{5}/_{16}$-in. size, thereby increasing the effective arc time and reducing stub loss. The length of an equal size fillet weld increases in proportion to the iron powder used in the coating. Likewise, the surface appearance is improved with iron-powder modification. The fillet profiles show a tendency for convexity with the E7016 but this convexity is less pronounced with the 30% iron-powder modification and disappears entirely with the 50% iron-powder type leaving a slight concave profile. The penetration pattern of the 50% iron-powder type (Fig. 1, top) is wider and more shallow than the other two. This is due to the thicker coating dragging on the vertical and horizontal legs of the fillet, not allowing it to get as close to the corner as the other two types which have thinner coatings. A better comparison, perhaps, would be to use a $^{5}/_{32}$-in. electrode for the heavier 50% iron-powder type and $^{3}/_{16}$-in. size for the other two types. Excess metal used in forming a convex surface is all wasted since it adds nothing to the strength of the fillet. A concave fillet, on the other hand, is undesirable since it weakens the weld by reducing the throat thickness. Therefore, the flat profile, such as that produced by the 30% iron-powder type electrode, is the most desirable.

Figure 2 shows single and double beads deposited in a single-V butt joint having a $^{1}/_{2}$-in. root opening, 45-deg included angle, and $^{1}/_{4}$-in. thick backing plate, made with a $^{3}/_{16}$-in. electrode in the flat position for each of the three groups. The optimum amperage as given in Table 2, using d-c reverse polarity, with little or no weaving of the electrode was used in depositing

Table 2—Recommended Welding Currents for Normal Welding Conditions of the Three Groups of Low-Hydrogen Electrodes Tested

Electrode No.	Electrode type	Size, in.	Welding amperage—Horizontal and flat	Welding amperage—Vertical and overhead
1, 2, 3	E7016	5/32	160–180	130–140
		3/16	200–240	150–160
		1/4	300–350	
4,5	E7016 modified with 30% iron powder	5/32	180–200	130–140
		3/16	240–260	150–160
		1/4	350–400	
6, 7	E7016 modified with 50% iron powder	1/8	175–215	120–135
		5/32	200–240	
		3/16	240–300	
		1/4	380–450	

the weld beads. A 1/2-in. root opening with a backing plate was used to accommodate the largest coating thickness of this group, namely, the 50% iron-powder type. In service a smaller root opening without backing would normally be used necessitating the use of a smaller size electrode for the heavy-coated 50% iron-powder modified type as compared to the other two types.

The profile characteristics of these weld beads show the same trend as those made in the horizontal fillets. The conventional E7016 shows a slight convex surface and the 30 and 50% iron-powder modifications are flat. The weld metal shows better merging or washing in at the side walls with the two iron-powder modifications. The weld-metal finish has a finer ripple and smoother appearance for both types of iron-powder modifications than for the conventional E7016, the ripple being finer and appearance smoother on the 50% modification. The slag removal is easier for the iron-powder types, with a preference for the 30% modification over that of the 50% type.

(b) Vertical Welding

Vertical up fillet welds (first and second layers) of all three groups are shown in Fig. 3. The appearance and speed of deposition in the vertical up position are better with the 30% iron-powder modification than with the E7016 type. The 50% iron-powder modification is not generally recommended for vertical welding, yet 1/8-in. and smaller sizes can be used fairly successfully for vertical up fillets. It is not as satisfactory, however, for open butt joints in the vertical. The greater fluidity and volume of slag causes the metal to run to the center and a much larger shelf of metal must be carried in order to approach a flat surface profile. For this reason the 50% type is not recommended for the vertical position.

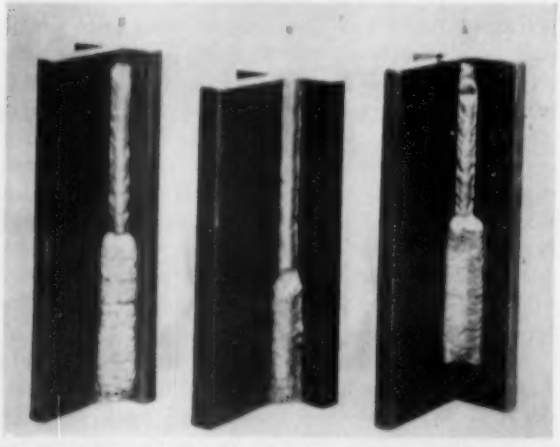

Fig. 3 Vertical up fillets, single and double layers. A, 1/8-in. and 5/32-in. E7016 50% iron-powder modified; B, 5/32-in. and 3/16-in. E7016 30% iron-powder modified; C, 5/32-in. and 3/16-in. E7016

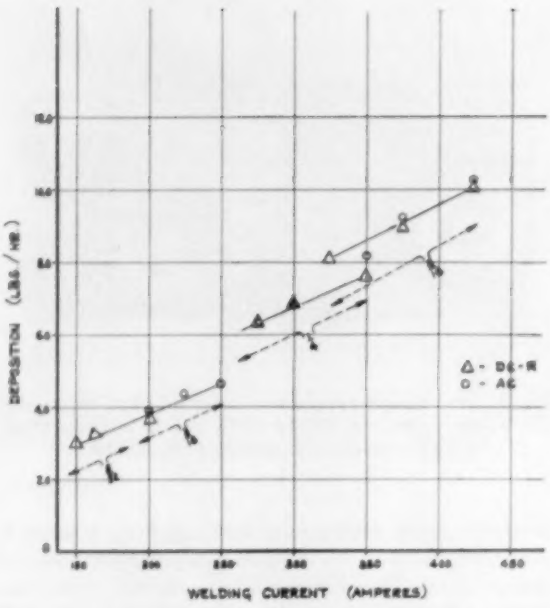

Fig. 4 Deposition rate of a conventional E7016 electrode

(c) Alternating vs. Direct Current

Comparing the operational characteristics on ac vs. dc, much can be said in favor of the iron-powder modification. Except for less arc blow with a-c, d-c reverse polarity is generally preferred with the E7016 types. This preference to the same degree is not experienced with the iron-powder modification groups. With the 50% modification, ac is usually preferred because of less tendency to fingernail or burn off unevenly due to the extra thick coating. The deposition rate as shown in Fig. 6, however, is less on ac, which may be undesirable from an economy point of view.

The coating thickness of the 30% modification is approximately the same as the conventional E7016 but the difference between ac and dc for arc stability is less. Furthermore, the deposition rate for ac, as shown in Fig. 5, is greater than the dc which seems to be peculiar to this group.

Efficiencies, Deposition and Burn-Off Rates

(a) Efficiencies

The efficiency as used here represents the percentage

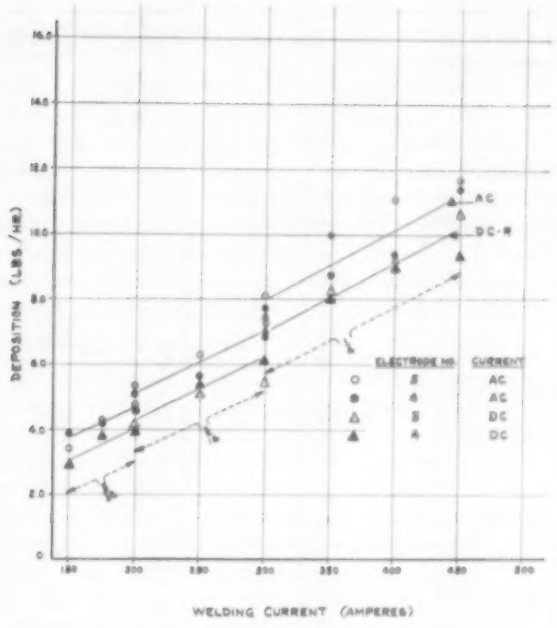

Fig. 5 Deposition rates of two low-hydrogen 30% iron-powder modified type

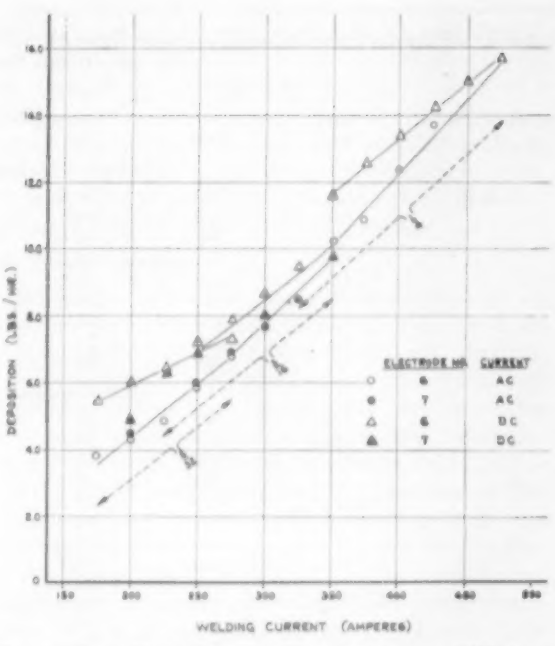

Fig. 6 Deposition rates of two low-hydrogen 50% iron-powder modified electrode

by weight of electrode that goes into the weld-metal deposit exclusive of the stub loss. Figuring about 10% for the stub loss would reduce these values by this amount for actual service applications. The efficiencies, deposition and burn-off rates for the three groups are given in Table 3. The efficiences for the 30% iron-powder modification are from 6 to 8% higher than for the conventional E7016, whereas the 50% modification are approximately the same.

(b) Deposition and Burn-Off Rates

Since the burn-off and deposition rates have the same trend, only the deposition rates were plotted graphically to show this trend. Figures 4, 5 and 6 give the deposition rates for the three groups in all sizes. Figure 7 compares the $^{5}/_{16}$-in. size of each group which shows the trend quite distinctly. The E7016 group was the average of the three brands while the 30 and 50% modification groups give the individual values obtained on each brand and size tested. The curves of the two brands of the 50% modification are very close together. The d-c values are about 10 to 15% higher than the ac at the lower amperages but fall very close together at the top of the range. The difference between ac and dc for the 30% modification is about the same throughout the whole range and approximately the same as the 50% at the lower side of the range. The peculiar difference, however, is that the deposition rate with ac is greater than with dc. This may be explained by the inherent differences in the two types of coatings. The 50% modification is a titania-type coating whereas the 30% is a lime type. The peculiarity of this difference is in the fact that titania-type coatings have always been considered ac, dc types and the lime type as

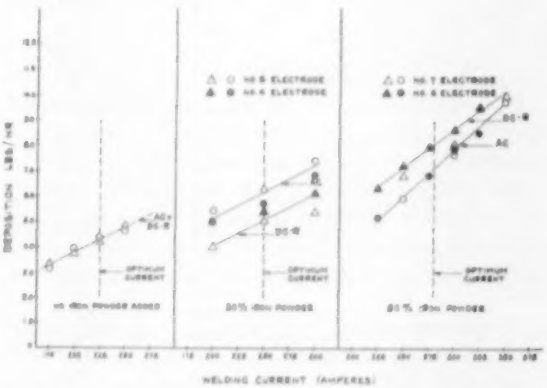

Fig. 7 Deposition rates of $^{5}/_{16}$-in. diam E7016 electrodes vs. two iron-powder modified types

dc only. The authors feel that this is in general a misconception and this 30% iron-powder modification quite strikingly bears it out.

The conventional E7016 containing no iron-powder additions have about equal burn-off and deposition rates. The deposition rates were made with an a-c welding machine having 80 or higher open-circuit voltage. Test values not given in this paper made with later model a-c machines having a lower open-circuit voltage show a difference of 8 to 10% between a-c and d-c reverse, for the conventional E7016 type, and about 5% difference for the 50% iron-powder modification than the values shown in Fig. 6, the ac in each case being lower than the dc.

Comparing the deposition rates at the optimum weld-

Table 3—Efficiency, Burn-Off and Deposition Rates of the Three Groups of Low-Hydrogen Electrodes Containing 30%, 50% and No Iron Powder in the Coatings

Electrode No.	Size, in.	Amp	Efficiency, % ac	Efficiency, % dc-r	Burn-off rate, in./min ac	Burn-off rate, in./min dc-r	Deposition, lb/hr ac	Deposition, lb/hr dc-r
			(Conventional E7016)					
1, 2, 3	5/32	150	70.0	70.0	9.4	9.7	3.0	3.2
	6/32	175	68.5	68.0	10.9	11.0	3.5	3.4
	6/32	200	64.0	64.0	12.0	12.5	3.7	3.7
	5/16	200	71.0	71.0	8.7	9.3	3.9	4.2
	5/16	225	70.0	70.0	9.5	9.7	4.4	4.5
	5/16	250	68.0	67.0	11.2	10.7	4.7	4.8
	1/4	250	75.0	75.0	7.2	7.8	5.9	6.0
	1/4	300	73.0	74.0	8.1	8.3	6.5	6.8
	1/4	350	69.5	71.5	9.4	9.7	8.2	7.6
			(E7016 modified with 30% iron powder)					
4	5/32	150	74.0	75.0	9.2	8.2	3.4	2.9
	6/32	175	76.0	76.0	11.2	10.2	4.3	3.8
	6/32	200	73.0	75.0	12.9	11.4	4.7	4.3
5	5/32	150	76.6	76.6	10.6	8.1	3.8	2.9
	6/32	175	77.6	76.8	11.4	10.2	4.2	3.7
	6/32	200	72.2	76.3	13.3	10.4	4.5	3.8
4	5/16	200	77.0	76.8	10.2	7.8	5.4	4.1
	5/16	250	77.6	76.5	11.9	9.8	6.2	5.0
	5/16	300	74.8	67.7	13.2	11.5	7.4	5.3
5	5/16	200	78.4	77.1	9.4	9.6	5.0	5.1
	5/16	250	73.8	76.4	11.1	10.1	5.6	5.3
	5/16	300	70.4	73.2	14.1	12.2	6.8	6.1
4	3/8	300	81.1	81.2	8.9	8.2	8.2	7.6
	3/8	350	81.5	79.5	10.9	9.1	10.0	8.2
	3/8	400	78.7	79.2	12.5	10.6	11.0	9.5
	3/8	450	76.1	74.2	13.4	12.8	11.7	10.6
5	3/8	300	80.2	80.4	6.4	7.8	7.7	7.1
	3/8	350	80.2	78.2	9.5	9.1	8.7	8.0
	3/8	400	73.5	76.7	11.3	10.2	9.3	9.0
	3/8	450	73.5	71.8	13.7	11.5	11.4	9.4
			(E7016 modified with 50% iron powder)					
6	5/32	175	72.1	73.0	8.2	12.0	3.8	5.5
	5/32	200	73.5	73.0	8.8	13.2	4.2	6.1
	5/32	225	71.1	72.0	10.6	14.3	4.9	6.5
	5/32	250	73.2	72.5	12.7	15.2	5.9	6.9
	5/32	275	71.7	71.0	14.5	15.9	6.8	7.3
6	5/16	275	73.0	74.0	10.1	11.6	6.9	8.0
	5/16	300	72.0	74.0	11.4	12.8	7.8	8.7
	5/16	325	69.0	71.0	13.3	14.0	8.5	9.5
7	5/16	250	70.2	67.6	8.1	9.7	5.9	6.9
	5/16	300	68.0	64.7	10.9	11.8	7.7	7.9
	5/16	350	69.1	65.0	13.8	14.7	9.9	10.0
6	3/8	375	73.7	72.0	9.0	10.6	10.9	12.6
	3/8	400	73.2	72.0	10.3	11.3	12.4	13.4
	3/8	425	72.3	72.0	11.5	11.9	13.7	14.2
	3/8	450	72.2	72.1	13.1	12.6	15.7	15.0
	3/8	475	70.6	70.0	13.4	13.3	15.7	15.8

Table 4—Weld Metal Analysis and Mechanical Properties of the Three Conventional E7016 and Four Iron-Powder Modified Electrodes Tested

Electrode No.	Weld-metal analysis, % C	Mn	Si	S	P	Mechanical properties: Tensile, psi	Yield, psi	Elongation in 2 in., %	Reduction in area, %
1	0.12	0.91	0.54	0.020	0.011	78,500	68,100	31.0	72
						78,500	68,000	30.0	72
2	0.08	0.88	0.37	0.022	0.017	70,500	59,200	33.0	75
						70,000	58,600	35.0	75
3	0.07	1.09	0.51	0.014	0.011	82,500	73,000	31.0	74
						82,250	73,000	29.5	73
4	0.05	0.93	0.76	0.013	0.010	82,200	72,000	32.5	71
						82,200	72,000	31.5	71
5	0.09	0.83	0.72	0.015	0.011	76,500	64,250	30.5	74
						79,000	67,000	31.0	73
6	0.11	0.86	0.51	0.024	0.022	76,500	62,000	30.0	70
					Ni 0.52	75,500	62,500	31.0	70
7	0.07	0.84	0.43	0.032	0.018	75,750	62,250	32.5	71
						73,250	65,000	32.0	73

ing current for each group, the 30% modification is about 30% faster on ac and 20% faster on dc than the E7016. With the 50% modification, this difference is about 60% faster on ac and 80% faster on dc. This difference becomes quite significant in the economy of making a weldment when it is realized that about 80% of the total cost of a weldment is in the labor and overhead. It is not the intent of this paper to give data showing the exact extent of saving that can be realized from the use of these faster welding electrodes but it suffices to point out the possibilities in this direction.

Mechanical Properties

The mechanical properties of the three groups of electrode weld-metal deposits together with their chemical analyses are given in Table 4. There is no significant difference in any of them, either in the chemical analysis or the mechanical properties. Electrode No. 2 of the conventional E7016 type is slightly lower in tensile and yield strength and perhaps should be rated as an E6016. Otherwise, the other six are very similar. Electrode No. 6 has about 0.5% nickel in the weld metal and the silicon contents of electrodes Nos. 4 and 5 were slightly higher than the others. Otherwise, they were very similar. This similarity of weld-metal chemistry and mechanical properties should help dispel any tendencies of code-writing bodies to restrict the use of these iron-powder modification types where E7016 is specified.

Impact Properties

The Charpy-Vee impact transition curves are shown in Fig. 8. Impact values above room temperature were not determined since it was felt they have no significance for the intended application of these mild-steel electrodes. Note that the small difference in the transition curves is no greater than the reproducibility spread that might be expected among production lots and laboratory testing techniques. All three conventional E7016 electrodes gave impact strength values higher than the 30% iron-powder group yet the transition temperature seems to be in the same range for all of them. According to some of the best authorities in this field the significance of the impact properties is not in the individual values at any one temperature but the temperature of transition from the ductile to a brittle behavior of the metal. Since the impact values for all nine electrodes are so close together we again feel that there should not be any restrictions by code-writing bodies in the use of these iron-powder modifications of the E7016 types for quality welding.

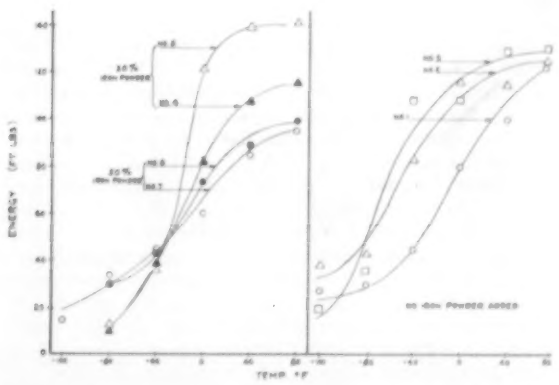

Fig. 8 Comparison of Charpy V impact curves of conventional 3/16-in. E7016 electrodes vs. two iron-powder modified types

Moisture Sorption

Studies are in progress on moisture sorption in the coating and its effect on the operation of the electrode and the quality of the weld-metal deposit. Preliminary tests show a wide spread in the rate of moisture absorption among the conventional brands. Likewise a variation between the brands of iron-powder types exists which is not quite as pronounced. In general the rate of moisture absorption for the nonmetallic constituents in the coatings of the iron-powder groups is greater than for the conventional types but their redrying characteristics show a more rapid moisture loss than the conventional type under similar drying conditions. While these studies have not progressed to a point where conclusions can be drawn, we feel that equal or greater precautions should be taken in the care and storage of low-hydrogen iron-powder electrodes than for the conventional types.

Summary

Iron-powder low-hydrogen electrodes are available in American brands today in both lime- and titania-type coatings. The lime type has approximately 30% iron-powder additions and is suitable for all-position welding. The titania type has approximately 50% iron-powder additions and is generally recommended for only horizontal- and flat-position welding, although the 1/8-in. and smaller sizes can be used for all-position work.

Their greatest single advantage over the conventional E7016 types is in increased weld-metal deposition rate. The 30% iron-powder modification has from 20 to 30% greater deposition rate and the 50% iron-powder modification has from 60 to 80% greater deposition rate than their conventional counterpart when used at the optimum welding current. They have an easier slag removal, improved bead appearance, and the mechanical properties in general are equal to their conventional counterpart. They have better operator appeal because of the steady, smooth arc characteristics.

The rate of actual moisture absorption by the nonmetallic materials in the coating in general is greater than the conventional types and equal precautions should be observed in the storage and care of these electrodes. The redrying characteristics are much the same.

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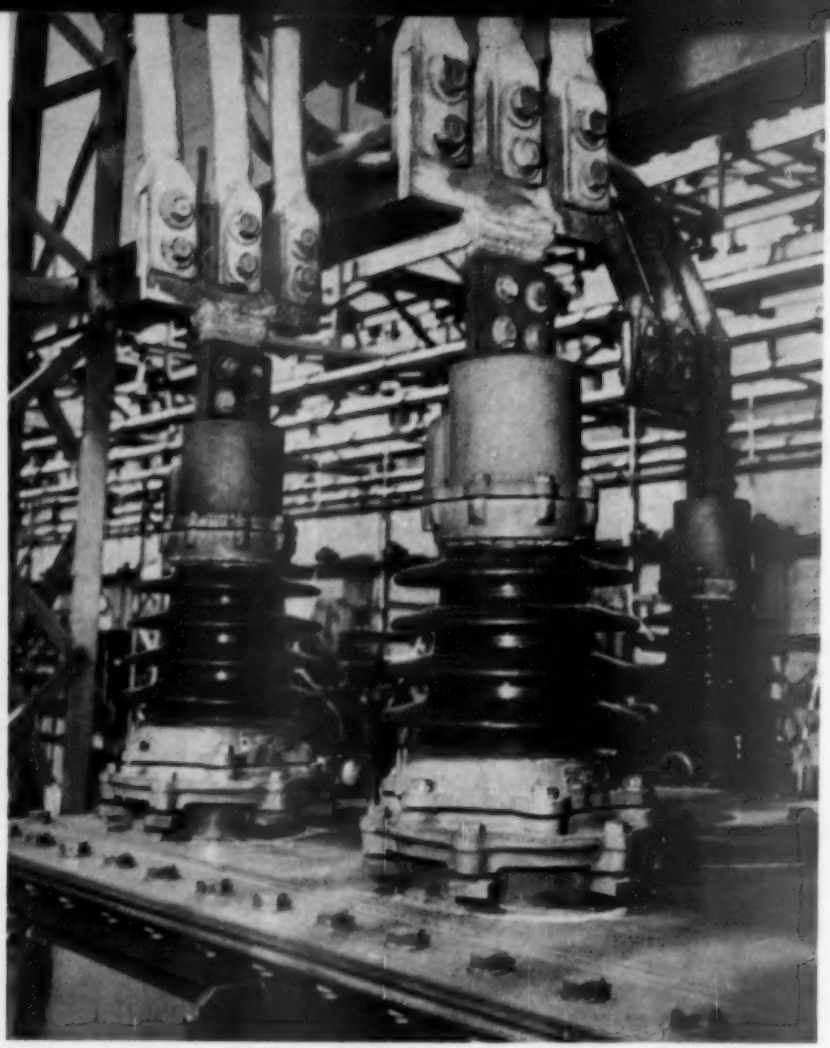

Typical application of copper-aluminum braze-welded joints used in 60,000-kva step-voltage regulator connections

WELDING ALUMINUM TO COPPER USING INERT-GAS METAL-ARC PROCESS

Increasing use of aluminum busbar for elevated temperature service in combination with existing copper bus systems has led to the development of this method for braze welding aluminum to copper

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SUMMARY. Aluminum bus, now being used extensively, can usually be connected to aluminum or to copper by properly designed bolted joints. However, where elevated temperatures are encountered, a welded joint is needed to provide good service.

The increasing use of aluminum busbar for elevated temperature service in combination with existing copper bus systems has increased the need for a method of arc welding aluminum to copper. The paper describes in detail a method whereby this can be accomplished*. The portion of the copper to be joined to aluminum is first coated with a silver solder, using standard silver brazing procedures. The aluminum and the silver solder-coated copper are then welded together using standard consumable-electrode inert-gas metal-arc welding methods. The silver solder serves as a buffer layer to prevent the excessive formation of brittle $CuAl_2$ during welding. The mechanical, electrical and metallurgical characteristics of joints of various designs, which were found to be satisfactory, are described in detail. Quality

* The process described in this paper is protected by patent rights of K.A.C.C.

control methods are described with illustrations of typical joints. Braze-welded joints have been tested extensively under severe operating conditions and have given excellent, maintenance-free service.

Introduction

Aluminum busbar is now being used extensively for carrying large electrical loads in many types of service. In most applications of aluminum busbar, correctly designed mechanical connections such as bolted joints and compression fittings can be used successfully for joining aluminum either to aluminum or to copper. However, bolted joints subjected to thermal cycling or to elevated temperature service, even though they are correctly designed, may not be satisfactory because of the gradual deformation of the aluminum under compression and because of the gradual oxidation of the contact faces. The oxide at the interface causes some power loss with increased temperature at the joint. The net result is that these two factors combine to cause an accelerating deterioration of the electrical connection. This results in high maintenance costs or ultimate failure of the joint. Silver plating of the contact surfaces effectively prevents or reduces oxidation; however, it does not prevent gradual deformation caused by compression. For service at elevated temperatures, then it is desirable to weld a copper member to the aluminum so that the bolted joint will be copper to copper or copper to steel, rather than aluminum to aluminum or aluminum to copper.

In some instances, space considerations may not permit the installation of an aluminum to aluminum bolted joint for operation at ordinary temperatures because the current density on well-designed bolted joints must generally be held to a maximum of about 100 amp per square inch. The welding of a copper member to the aluminum to allow a copper to copper bolted joint would permit the use of a somewhat higher current density and a correspondingly smaller joint.

A method of obtaining satisfactory, ductile welds in arc-welded copper-aluminum joints has been the limiting factor in making a welded connection between these two metals. Aluminum and copper have been satisfactorily joined by soldering, brazing, flash butt welding and pressure welding; however, each of these processes has its limitations, and a method of arc welding aluminum to copper was very much needed.

If arc welding is attempted directly between aluminum and copper, several problems are encountered. The most important of these is the formation of the brittle intermetallic compound $CuAl_2$. This, of course, makes the joint brittle and subject to cracking under impact or low stresses. This difficulty has been overcome by using a newly developed process in which a buffer layer of silver solder is provided between the copper and aluminum.

Description of the Copper-Aluminum Welding Process

To obtain satisfactory arc welds between aluminum and copper the joining operation is carried out in two steps. The weld area of the copper member is first coated with a $^1/_{32}$-in. layer of BAg-3 silver solder. This silver alloy consists of approximately 50% silver, 15.5% copper, 16.5% zinc and 18% cadmium. It has a melting point similar to that of the aluminum filler metal. Brittle joints are eliminated since both the copper and aluminum are metallurgically compatible with the buffer layer, i.e., they do not form excessive amounts of brittle intermetallic compounds.

In preparation for applying the silver solder, the surface of the copper is degreased and wire brushed. The silver solder is then applied using standard silver brazing methods. The coated copper is then water quenched and wire brushed to remove the silver solder flux.

The silvered copper section is positioned on the aluminum and welded with 4043 filler wire using the inert gas metal-arc process. Welding procedures are similar to those used for aluminum welding, except that the arc is not directed on the silver solder face. A backwashing motion forces the molten aluminum filler metal up against the silver solder to permit fusion with the silver buffer alloy without excessively melting it. Interpass temperatures are held below 350°F by interpass cooling to further reduce dilution of the silver solder in the weld metal. The surfaces of the silver solder and weld beads should be wire brushed to keep them free of dirt and oxides to assist in the production of sound joints.

Because this joining technique is accomplished in two steps, braze coating and inert-gas metal-arc welding, the joint is referred to as a braze weld.

Joint Design

Preliminary tests showed that the electrical conductivity is always adequate where the design produces adequate strength. Emphasis was therefore placed on evaluating the mechanical properties of various joint designs. Three main types of joint design have been investigated. These are shown in Fig. 1 along with modifications of each joint type. The highest joint strengths are obtained with either the tee or lap joint design, because a locking action is obtained by the aluminum fillet around the copper member in these cases. The higher coefficient of thermal expansion of aluminum as compared to copper causes the aluminum fillet to shrink tightly on the copper member as the weld

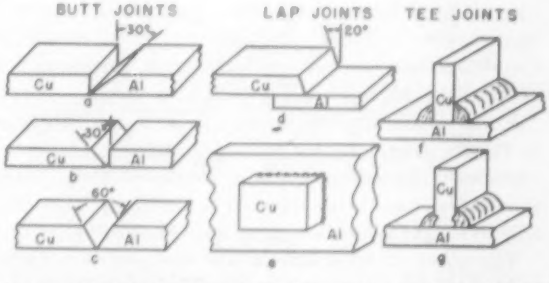


Fig. 1 Sketch showing butt, lap and tee joint designs which have proved successful for braze welding copper to aluminum

is cooled. This, of course, produces a joint with improved mechanical properties because the interface is in compression. By using a keyed joint design, Fig. 1(*g*), additional strength can be obtained, although this is not necessary for most applications. Butt welds have also given satisfactory results in several applications, particularly in attaching an aluminum flexible section to a solid copper terminal.

Typical joints of an aluminum flexible section butt welded to a copper bar and broken in tension are shown in Fig. 2. Each of these test samples broke in the aluminum flexure near the weld. Other typical fillet joints are illustrated in Figs. 3 and 4. Figure 3 illustrates a tensile specimen, prior to testing, which was cut from a quality control sample. Figure 4 shows fractured tensile specimens for three other joint designs. Specimens shown in Fig. 4 were tensile tested at 400°F.

Properties of Copper-Aluminum Braze-Welded Joints

Copper-aluminum braze-welded joints in electrical bus systems must have good electrical conductivity, reasonable strength and resistance to impact loads. It is important that the joints withstand thermal cycling resulting from current variations or changes in ambient temperature. It is also necessary that the joints maintain good mechanical and electrical properties at elevated temperatures.

Mechanical Properties

A large number of tests have been conducted to determine the mechanical properties of copper-aluminum braze-welded joints. Table 1 lists the tensile properties of copper-aluminum inert-gas metal-arc welded joints which were subjected to 500 cycles of alternate heating to 400° F and cooling to 150° F. This table also contains tensile data on samples which were soaked at 450° F for 2 weeks. In each case, no significant deterioration in mechanical properties was observed. Tensile tests at elevated temperatures indicated a high joint strength, with fracture occurring in the parent aluminum member. Figures 4 and 5 illustrate the designs and typical fracture locations of these joints. To further evaluate the mechanical properties, a series of bend tests were made on tee joints. Specimens, 1 x 1 in. illustrated in Fig. 6, were clamped with the aluminum end in a vise. The weld was approximately 1 in. above the vise jaws. A force applied on the copper end was designed to place one fillet in tension and one in compression. While normally no joint would be required to take such severe forming, it is reassuring to know that such deformation can be sustained.

Joints similar to those shown in Fig. 6 were subjected to severe impact before failure occurred. The specimens were clamped in a vise as described above. The copper end was then subjected to multiple blows with a 70-lb weight until the copper was bent 90 deg.

The effect of fillet size on the strength of a braze-welded tee joint is shown in Fig. 7. It was found that the breaking load for a double-tee fillet increased directly as the fusion area increased. Shear strength at the

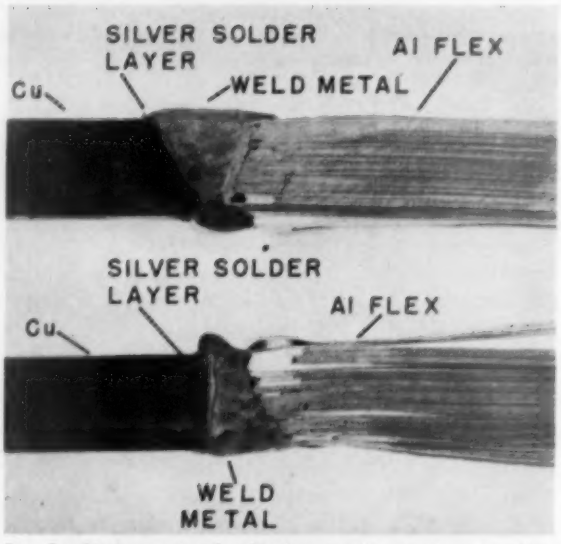


Fig. 2 Photograph of a broken tensile specimen used to determine properties of two copper-aluminum braze welds

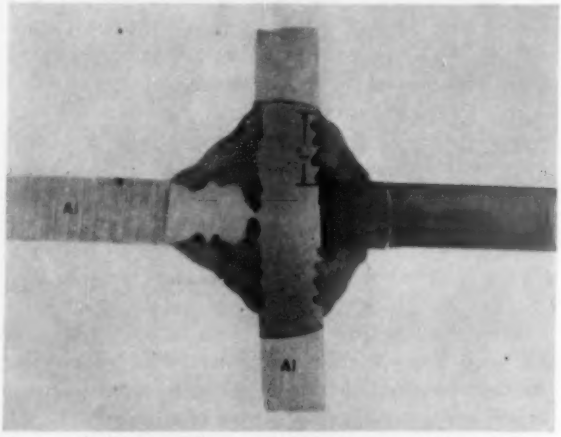


Fig. 3 Side view of a tensile specimen machined from a quality control sample of a braze-welded double-tee joint. Weld made between a copper plate ¾ in. thick and an EC aluminum plate 1 in. thick

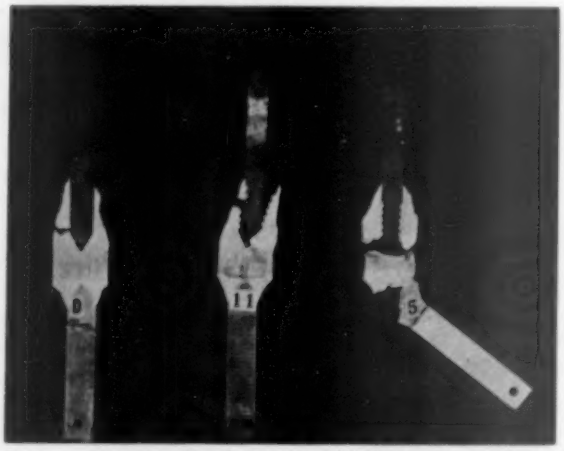


Fig. 4 Photograph of braze-welded tensile specimens tested at 400° F. Specimens were cut from a welded plate; the copper ¾ X 4 in. and the EC aluminum 1 X 4 in.

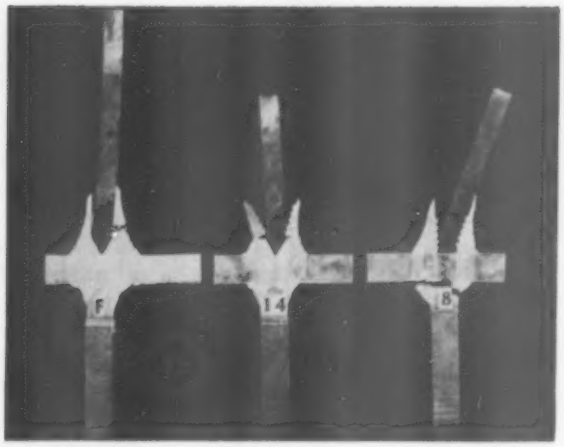


Fig. 5 Photograph of braze-welded tensile specimens tested at room temperature after holding at 450° F for 2 weeks

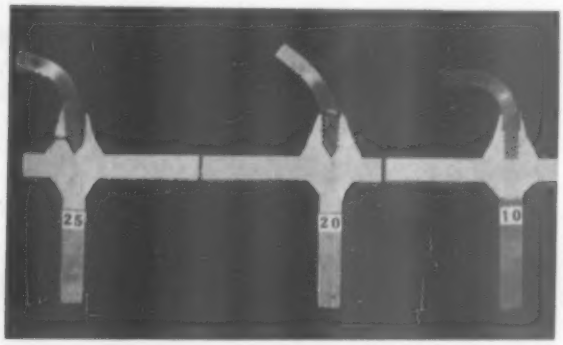


Fig. 6 Photograph of braze-welded bend test specimen after they were fractured in a free bend test

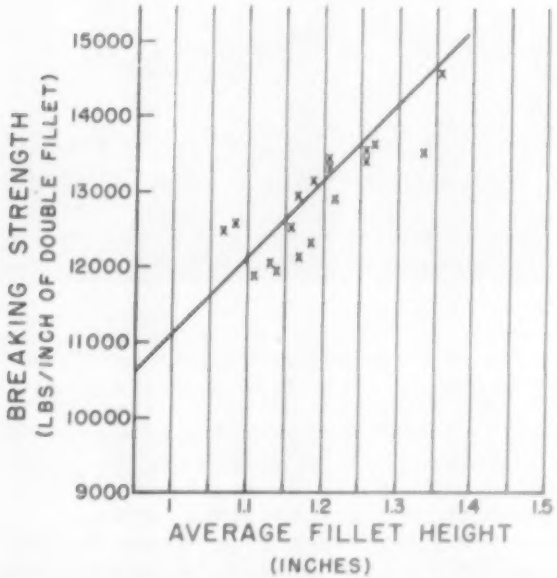


Fig. 7 Chart showing the effect of fillet size on breaking load of braze welds made in plate; the copper was ¾ in. thick and the EC aluminum was 1 in. thick

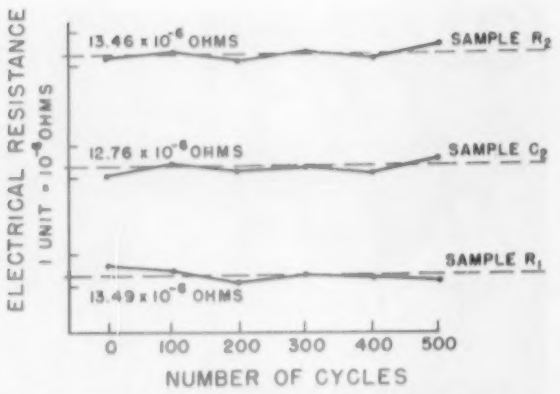


Fig. 8 Graph showing effect of thermal cycling on the electrical resistance of copper-aluminum braze welds

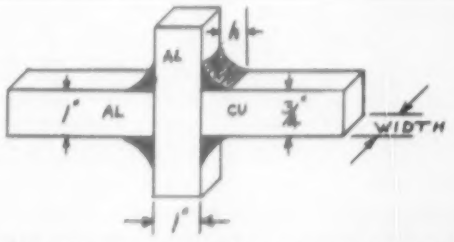
interface of these test joints was found to be somewhat greater than 6000 psi of interface.

Electrical Properties and Effects of Thermal Cycling

In addition to the mechanical testing outlined above, measurements were also made to determine variations of electrical resistance of the joints. Figure 8 illustrates the effect of thermal cycling on the electrical resistance of the joints. The resistance of each joint which was subjected to thermal cycling was measured at each 100 thermal cycles. Each measurement recorded was the average of 5 resistance determinations. Because the resistance varied only slightly as the cycling progressed,

Table 1—Results of Mechanical Tests on Double-Fillet Braze Welds*

Condition of test specimen	*fillet size, in.*	*Breaking load, lb/in. of specimen width*	*Location of fracture*
As-welded	1¼	12,600	At interface and fillet
After 500 cycles of heating to 400° F and cooling to 150° F	1¼	11,700	At interface and fillet
After soaking at 450° F for 2 weeks	1¼	12,100	At interface and fillet
Tested at 400° F	1¼	9,150	In aluminum busbar



* Braze welds were made on plate; the copper being ⅝ x 3½ in. and the EC aluminum 1 x 3½ in. in section. The design is a tee joint with two fillet welds, one on each side of the vertical member. Fillet size or height is given by the dimension h.

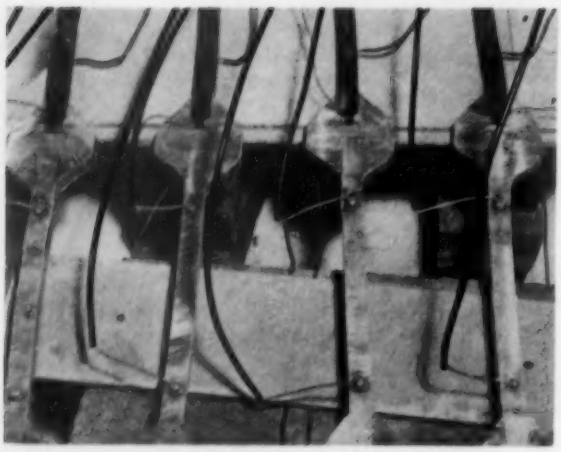


Fig. 9 Photograph of braze-welded test specimen mounted in an insulated box to determine effect of electrical and thermal cycling on mechanical and electrical properties

all of the values were averaged and the grand mean of all readings is shown as a dotted line on the curves. Of all the samples tested, the sample which showed the highest variation after 500 thermal cycles had an increase of 13.58% in resistance. All the other samples tested varied less than 3% from the grand mean. In several cases the greatest deviation did not occur at the 500 cycles measurement as anticipated but during some intermediate stage. This indicated that variations in resistance were not a function of the number of thermal cycles. Results of these accelerated tests have been verified in actual operation of these joints.

In addition to the thermal cycling described above, test samples were also prepared and subjected to thermal and electrical cycling loads. Eight copper-aluminum joints were welded in series and inserted in an insulated box as shown in Fig. 9. For this series of tests $^5/_8$-in. thick copper busbar was used and 1-in. thick aluminum busbar. After the weld was made, the samples were machined flat to 1 in. thickness in the joint where the measurements were to be made. Potential terminals were tapped into each sample 3 in. on either side of the joint and reference potentials were tapped across 6-in. lengths of copper and aluminum busbar. Thermocouples were peened into each of the copper bars in the center section of the copper in the joint. Resistance heating caused by an applied electrical load of 1100 amp raised the joint temperature to approximately 400°F. Thermal cycles were established with current alternately on for 2 hr and off for 2 hr. These samples were subjected to 579 such cycles with no indication of a decrease in electrical conductance. Table 2 shows the temperature of each joint and the corresponding voltage drop across the joints. The voltage drop across the joint was no greater than that

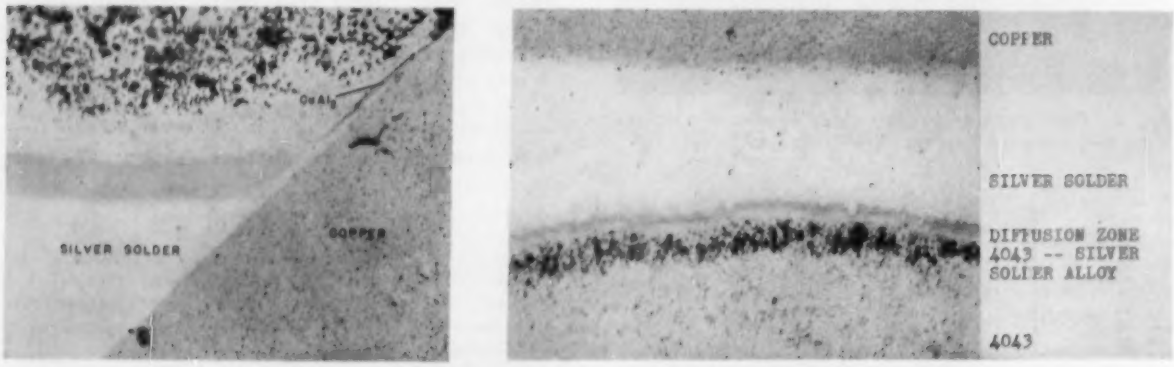


Fig. 10 Photomicrograph of section across a copper to aluminum braze-welded test specimen

Table 2—Table Showing Potential Drop During Thermal Electrical Load Cycling of Copper-Aluminum Braze-Welded Joints

	Samples No.																*Control copper,*	*Aluminum,§*
	1		*2*		*3*		*4*		*5*		*6*		*7*		*8*			
*No. of cycles**	*°F†*	*MV‡*	*°F*	*MV*	*°F*	*MV*	*°F*	*MV*	*°F*	*MV*	*°F*	*MV*	*°F*	*MV*	*°F*	*MV*	*MV*	*MV*
1	379	26.8	393	24.8	357	24.4	364	24.7	370	26.2	351	29.8	390	23.8	398	25.0	52.4	66.0
12	411	30.0	425	28.0	390	27.3	396	28.3	401	29.2	411	27.6	420	24.4	420	27.2	55.2	69.0
24	410	27.2	419	24.8	390	24.0	400	24.6	404	26.0	404	24.6	385	23.4	419	24.6	50.4	66.8
84	405	28.8	420	27.0	381	26.2	394	26.8	397	27.2	398	28.6	375	27.0	414	28.2	57.2	76.8
109	417	32.0	425	30.0	422	30.2	435	29.5	433	30.6	432	28.8	414	27.6	455	28.8	56.8	77.8
251	407	29.3	399	25.3	408	26.8	390	28.2	392	29.6	380	27.2	369	27.6	389	26.2	56.6	62.2
579	370	25.8	374	23.5	371	23.4	364	24.8	360	26.2	348	24.0	338	24.4	350	23.6	49.0	

* One cycle consisted of current on for 2 hr which raised the joints to about 400° F and current off for 2 hr which cooled the joint to about 68° F.

† Temperature of sample during measurement.

‡ Millivolt drop measured across 3 in. of bus on each side of the joint.

§ Control consists of 6 in. of busbar outside of the joint area.

Table 3—Table Showing Chemical Analysis of Weld Metal Taken from Drill Holes in the Fillet Shown in Fig. 11. X-Ray Diffraction Studies Showed CuAl, and Ag_2Al Constituents in the Fillet

Sample	Chemical composition, % Ag	Cu	Cd	Zn	Total % Remainder Al
0	10	6	8	5.5	29.5
1	3.5	2.5	3.2	2.3	11.5
2	3.6	2.1	2.7	2.0	10.4
3	0.43	0.25	1.5	0.36	2.0
4	0.53	1.2	1.5	0.92	4.2
5	1.8	2.0	3.7	2.2	9.7
6	2.1	2.5	2.0	1.9	8.5
7	3.1	3.9	4.2	3.9	15.1

across a similar length of either the copper or aluminum member. It is, therefore, apparent that these joints will perform satisfactorily, from an electrical point of view, for service at elevated temperatures up to at least 400°F.

Metallographic Examination

A large number of metallographic samples were examined during the progress of this work and typical metallographic sections are shown in Fig. 10. At the top of Specimen 10*a* it can be seen that some $CuAl_2$ constituent has formed where there was no silver solder between the copper and the aluminum. This emphasizes the importance of having a uniform layer of silver solder on the copper before the welding operation is undertaken. The thin, black line at the top part of the photograph shows evidence of a crack which occurred in the area where the silver solder was absent. However, where there was an adequate layer of silver solder on the copper, no cracks were observed on any of the many samples examined. Figure 10*b* is a microsection showing the diffusion zones across the joint interface.

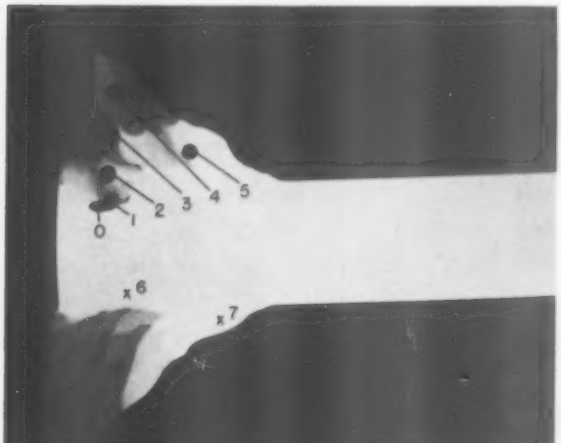


Fig. 11 Photograph of radiograph taken through a section of a copper-aluminum braze-welded test specimen, showing the copper tab, aluminum fillet and aluminum busbar

Radiographic Examination

A number of radiographs of these welded samples were prepared and a typical radiograph is reproduced in Fig. 11. The radiographs showed a tendency for the heavier elements from the silver solder to alloy with the aluminum filler material, particularly toward the top part of the fillet. X-ray diffraction studies indicated that these light areas on the radiograph, the zones of increased density of the weldment, resulted from the alloying of the weld metal with the heavy elements from the silver solder. As a result of these examinations, it was found desirable to keep the copper member of the joint area as cool as possible during the welding operation and to reduce the size of the fillets, particularly toward the top part of the member. In this way the excessive alloying of the filler metal with the silver solder, which occurred at the top part of the fillet, could be minimized. The small black holes shown in Fig. 11 are the locations of sample drillings taken for chemical analyses of the filler metal. Results of these analyses, shown in Table 3, indicate that a relatively small amount of heavy metal produced a very distinct change in the density of the X-ray plate. The hole marked −0 was drilled close to the copper and cut through part of the silver solder layer. The analysis for this hole is, therefore, not significant. In all of the other samples the amount of heavy elements present in the fillet is seen to be relatively small.

Corrosion Tests

A number of unprotected braze-welded aluminum-to-copper joints are being subjected to natural environment corrosion tests near the seashore at Daytona Beach, Fla. Corrosion test racks of these samples are shown in Fig. 12. Although for commercial installations it is always strongly recommended that the copper members be installed in a manner which will prevent the drainage of copper corrosion products on to the aluminum members, it will be observed that the test samples were exposed with the copper member at the top. This is the most corrosive condition, because the corrosion products from the copper drain down over the aluminum. The copper atoms accentuate corrosion of the aluminum by the galvanic effects resulting from contact of the aluminum with a dissimilar metal.

As a result of the severe exposure conditions at the Daytona Beach station, the entire sample, including the aluminum, has suffered some superficial corrosion after one year. There was, however, no measurable change in the electrical resistance of the joints. Visual examination after 20 months' exposure indicated no appreciable change since the examination after one year of exposure.

Quality Control

Although this method of copper-aluminum welding has proved to be satisfactory in large commercial operations and good consistency has been obtained, it is necessary to maintain sound inspection procedures to insure high quality welds. Inspectors should be familiar with the process and they should keep close control of every

Table 4—Standard Procedure Form for Silver Solder Coating and Welding of Copper to Aluminum

Material: Copper, $^{13}/_{16}$ x $3^{1}/_{2}$ in.; E. C. aluminum, 1 X 12 in.

Material Preparation:

A. Copper

1. Machine copper
2. Degrease and wire brush surface to be coated
3. Flux with AWS Type No. 3 brazing flux
4. Apply $^{1}/_{32}$-in. thick (min) layer of BAg-3 or BAg-1 silver solder to copper (see sketch 1) using oxy-acetylene torch as heat source
5. Cold water quench
6. Wire brush to remove flux

B. Aluminum

1. Degrease and wire brush

Welding Procedure:

Material—

1. Filler metal—4043 Al $^{1}/_{16}$ or $^{5}/_{32}$ in. diam
2. Joint type—fillet or butt
3. Position welded—flat
4. Size of pass—approximately $^{1}/_{4}$ in.

Joining Details:

1. Gas and flow, argon 60 cfh
2. Current, 220–260 amp
3. Arc voltage, 24–28
4. Arc length, $^{3}/_{16}$ to $^{5}/_{16}$ in.
5. Tacking centers, each end of joint
6. Other

Wire brush between passes

Stagger welds to maintain temperature at less than 350° F

Stagger welds to minimize distortion stresses

Maintain arc on aluminum base metal while maintaining a molten weld pool to tie in with copper

step of the procedure since most of the inspections must be visual.

Steps in quality control inspection should include:

1. Checking of cleaning methods and effectiveness of the cleaning process.

2. Checking of silver solder overlay procedure to insure that a good bond is obtained and the correct thickness of silver solder is applied to each copper surface.

3. Checking of cleaning after the silver solder coat is applied to insure complete removal of the flux before the copper member is accepted for welding.

4. Checking welding procedures to insure that:

(*a*) The proper choice of filler wire has been made.

(*b*) The interpass temperature is held below 350°F.

(*c*) Surfaces between interpasses are cleaned.

(*d*) Finished dimensions are correct.

5. Obtaining quality control samples from each welder for destructive testing.

It has been established that a smooth silver solder coat is indicative of a good bond between the silver solder and the copper. Surface appearance can, therefore, be used as a criterion for accepting or rejecting the coated copper member for welding. Where the silver solder layer appears rough and/or has pinholes, then reheating and melting of the silver solder will disclose flux entrapment and cover-over. Therefore, the surface of the

Fig. 12 Photograph of corrosion rack with copper-aluminum braze-welded test specimens mounted for natural environment corrosion tests at Daytona Beach, Fla.

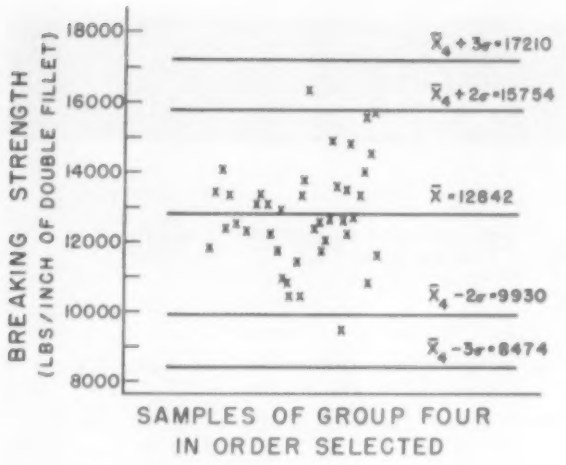


Fig. 13 Chart of tensile test results obtained on quality control specimens cut from braze-welded plates in which the copper was $^3/_4$ in. thick and the EC aluminum 1 in. thick

silver overlay should be checked carefully for pinholes and surface roughness. Where these are found, the copper member should be reworked.

The thickness of the silver solder layer must be controlled since too thin a coating increases the possibility of aluminum-to-copper contact during welding. The silver solder layer should not be less than $^1/_{32}$ in. thick on each surface, but no maximum limit of thickness is needed. Although coatings heavier than $^1/_{32}$ in. are not detrimental to the finished joint, they are not desirable from an economic viewpoint.

Complete flux removal is essential for good welding conditions. Any trace of brazing flux on the surface liquefies under the welding arc heat, causing the molten aluminum in contact with the flux to spatter away from the weld pool. This results in unsound welds and erratic welding conditions. Wire brushing is a very effective means of removing brazing flux. During brushing, pinholes which are not visible before buffing will be exposed at the surface. Brushing will also reveal the surface roughness resulting from flux entrapment, the brushed surface having a sandy appearance if flux entrapment is severe.

When production welding is first started, each welder should be given an opportunity to observe a trained welder working on a copper-to-aluminum joint, and he should be instructed in the proper techniques required for this type of welding. Each welder may then be given a qualification test which consists of welding a copper section to an aluminum plate. During this test it will be possible to check the welder's technique and take corrective steps wherever necessary. Samples should be subjected to tensile tests to determine strength and permit examination of the fracture.

Electrical properties need not be measured since laboratory tests indicated that welds which have satisfactory mechanical properties will also have satisfactory electrical properties. Conversely good conductivity may not insure good mechanical properties.

A number of tee joint designs, illustrated in Fig. 3, were prepared for visual examination and tensile tests. Figure 13 is a typical quality control chart prepared for these samples. The over-all average breaking load for all samples tested was 12,400 lb per in. of double 1-in. fillet with a lower control limit—2σ of 8800 lb per in. of double 1-in. fillet.

Applications

A typical application of braze-welded copper and aluminum busbar is shown in the lead illustration. The braze-welding technique made possible the installation of satisfactory joints under difficult conditions where clearances were limited and the conductors were large and unwieldy. The transformer was a 60,000-kva step voltage regulator. The three conductors shown are 1 million circular mil ACSR cables, installed with standard hydraulic press connections. Current loads on these lines run as high as 2500 amp per phase, which amounts to 168 amp/sq in. at the copper-to-copper bolted connection. This is too high a design factor for safe loading on a copper-aluminum bolted connection. To circumvent this, the cable lugs are bolted to an aluminum plate. This plate in turn is then braze welded to a copper tab which is bolted to the copper terminal of the transformer. This produces a neat and secure installation which gives excellent operating characteristics. Other applications similar to this have been operating successfully for several years. Generally speaking, the cost of fabricating joints such as those shown in Fig. 14 is equivalent to the cost of making a silver solder joint plus the cost of making an inert-gas metal-arc weld in a member of the same cross-sectional area. The advantages of using these joints, however, have proved in many applications to be well worth the additional cost of the joining process.

Conclusions

The results of this work show that satisfactory inert-gas metal-arc braze welds can be made between copper and aluminum bars. These ductile joints have good mechanical properties and electrical conductivity. Furthermore, they provide satisfactory operation under severe conditions of elevated temperature, thermal cycling or natural environment exposure.

The experience gained in this work has established that welders can readily be trained to make consistently good joints which have properties equivalent to those of the aluminum base metal.

RIGID FRAMES, SPACE STRUCTURES AND PLASTIC DESIGN

BY MARTIN P. KORN

As a member of the AMERICAN WELDING SOCIETY, and one of those who braved welded structural design thirty years ago, the author takes special pride in welding's spectacular contributions towards the coming "Golden Age of Engineering" in the field of structures. For nothing in all construction history had to fight its way so vigorously to live. Nothing like welding had to perform near miracles to survive in the longest obstacle race of all time.

Through the many obstructions set up in its way, welding has pushed forward in wedges by sheer superiority of performance until today the barricades of prejudice and fear have thinned down tremendously. In the future, there is visible a golden age in structural engineering by way of welding! Bigger and better rigid frames than ever before; spectacular frameworks, space structures of new world-record size and capacity; the application of plastic design for economy.

Rigid Frames

Welded gable bents and cathedral type structures were more frequently built in the early stages of welding than tier buildings. They punched a hole in all opposition to welding by their spectacular beauty, function and economy. Nothing in steel was so streamlined and simple. Hurtling over space in a single thrust of compacted strength without splices, without fortifications of steel at joints which were necessary in riveted design, they performed aloft as a symphony of stress and strain in monolithic steel!

Everyone is rigid framing today. You can count thousands of such structures around the country. Some are designed well, others not so well, with or without benefit of the best knowledge available. Each one built affords a stimulus for bigger and better rigid frames in the future. Figure 1 is a typical rigid frame structure of modern design, with a span of 180 ft.

While details are now becoming standardized to some extent, it behooves every designer to round out his theoretical knowledge with study before proceeding with more advanced types of structures. In THE WELDING JOURNAL Research Supplement, beginning with the July 1951 issue, are found the most valuable data covering portal frames, especially knee data. Several items of importance still performed without good judgment by some designers will be discussed here.

Martin P. Korn is a Consulting Engineer, Boca Raton, Fla.

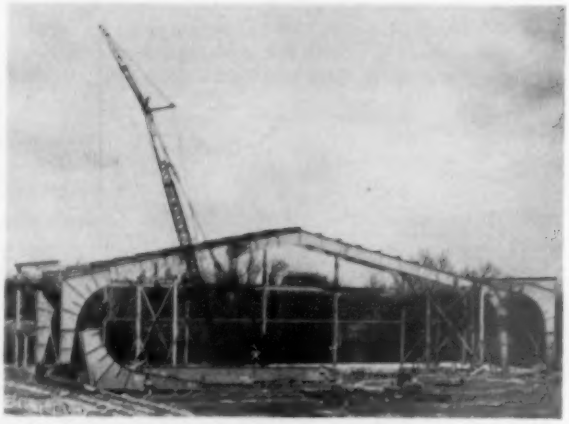


Fig. 1 Field house—Michigan State Normal College. Ypsilanti

The most common types of rigid frame designs are hinged. Employing such design does not mean that you have to use actual hinges. They are expensive and add immensely to costs of all structures. Figure 2, of all-plate construction, represents the hinge for above rigid frame of hinged design. It serves its purpose, is simple and least expensive. Flat plates could have been used for hinged bases in many existing structures which have expensive hinges. There are also

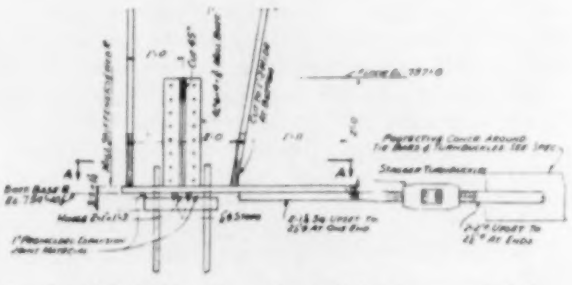


Fig. 2 Hinged column base for rigid frames, span 180 ft

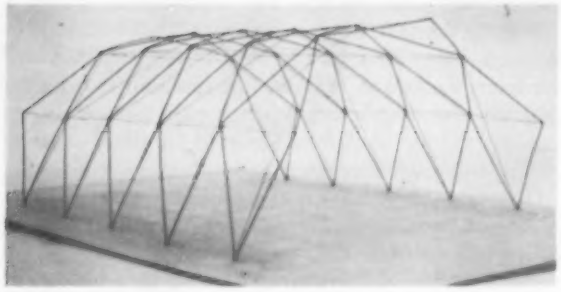


Fig. 3 Model of simple space structure

too many under 100-ft span with costly rockers for bases.

The question of when to use an actual hinge depends upon the ratio of the height of the legs (columns) to the span and also the pitch of the rafters. That ratio and the degree of roof slope fix the horizontal thrust. The shorter the columns by comparison to span, the larger the thrust. The flatter the roof, the larger the thrust. The thrust can thus become very big due to a combination of those two conditions, and when it gets too big you simply must use hinges or rockers; otherwise, the stress in the ties makes them too expensive to fabricate and install. Experience, good judgment and esthetic values can work to set roof slope and column heights to economical advantages.

While on the subject of hinged bases, some thought might be given to ties. Seldom, if ever, do design drawings say a word about erection of the rigid frame ties. Result: every fabricator leaves it to his "pusher" or superintendent, of whom no two are alike or think alike.

It is advisable that the engineer specify plainly on drawings or in specifications how the ties should be erected, just as he now specifies weld sizes which he formerly left to shop workers. If the deflection be held to a minimum by suitable spacing of supports, catenaries can be avoided and a sort of watch-like precision develops when the clevises or nuts are tightened. The workers are less likely to overstress or understress than at present with liberty unlimited. The season of the year must be taken into account and consideration made for extremes in temperatures.

Space Structures

When rigid frames meet and cross aloft they take another name—space structures. Figure 3, a model of rigid frames crossing one another, is a simple example. But in shape and form their variety is infinite such as pyramids, domes and all manner of interwoven frameworks.

Wherein do they differ and why this new name; is not every structure in space a space structure? Yes—literally; no—for stress distribution as we will presently learn.

A rigid frame is uniplanar, space structures are multiplanar; in other words, they are three dimensional. In three-dimensional frameworks, an applied force disperses in two or more planes. In a rigid frame (as the term is commonly used), an applied force disperses in just a single plane. The difference thus is in stress behavior pattern. When two or more rigid frames team up, they form a space structure.

Consider a rigid frame building with 3 bents 20-ft centers, in parallel planes. A force applied to any rigid frame is dispersed within that frame alone. Cross the three bents diagonally, join at contact points and apply the same force at any single spot. It will stress all three frames which have now become one space structure.

Try a rubber ball. Press down on it. Every part is affected. The stress distributes in all directions which is characteristic of domes and explains why they are space structures.

Figure 4, an elliptical space structure, 300 × 400 ft., employing welded rigid frames is a preliminary design (by author) of the proposed Detroit Convention Hall. It reveals the singular beauty and majestic grace that

Fig. 4 Preliminary design—Detroit Convention Hall

welded design can contribute to structures of magnitude.

You now know everything about space structures, except to ask what good are they? Answer: they make the most economical frameworks for the larger structures and take the biggest collapse load. The bigger the space to be enclosed, the more economical becomes a structure, especially the closer it approaches a sphere in form.

Plastic Design

If the author remembers correctly, a Dutch Engineer-Contractor Kist at a Convention in Holland in 1917 was the first one to challenge the economics of traditional elastic design. To him, design by ultimate strength was the only method for economy because it was realistic.

What is the basis for such a thought? A fact known to many today that in any rigid frame construction, the reserve strength is of such magnitude as to give the structure as a whole much greater load carrying capacity than computed theoretically by elastic design, leading to greater economies.

Of special importance and significance to every one connected with welding, those economies in steel will derive mainly from use of welded construction, since connections play a key role in assuring that the structure attains its computed load.

Conclusion

As we stand on the threshold of the Golden Age of Engineering—the future of welding appears bright and unlimited.

LOW-HYDROGEN ELECTRODES MAKE PREHEATING UNNECESSARY

BY GEORGE BAIN

Some of the lift trucks built by the Battle Creek, Mich., plant of Clark Equipment Co., employ an assembly in which steel castings have to be arc welded to the ends of long channels of SAE 5145 steel, used in pairs. As cracking of such welds can be avoided if the components are properly preheated, this practice was followed initially and produced good results. It was found, however, that the preheating was awkward and required much time and expense.

It has now been established that good welds can be produced without cracking even if preheating is omitted, if the proper grade of low-hydrogen electrode is employed; hence, this procedure is now followed, using the trunnion fixture shown in Fig. 1. As downhand welding is faster and more convenient and the assemblies are quite long, the welder has to stand on a scaffold to reach the high welds when the assembly is held vertically.

For convenience, the assembly is fabricated (after initial tack welding) on a fixture having its trunnion pin support attached to the side of the scaffold. This is so arranged that, when channels held in the fixture are vertical, their upper ends are conveniently accessible by a welder standing on the scaffold platform, reached by a ladder. External welds are thus made downhand from the scaffold. A welder standing on the floor makes internal welds on the end of the assembly that is down.

When one set of welds has been completed, the fixture and weldment are turned end for end, bringing the weldment to a position such that the remaining welds can be made downhand. In the illustration, the weldment is horizontal so that external welds, made at one end when this end was up, can be seen readily.

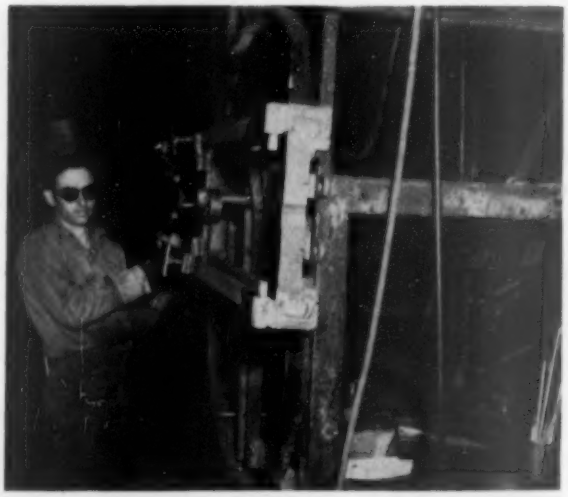


Fig. 1 Weldment consisting of cast steel end portions welded to SAE 5145 steel channels. Here the weldment is shown horizontal, but welding, using low-hydrogen electrode, is all done downhand with the weldment vertical, external welds being made with the operator on the scaffold to which the fixture is pivoted

E-7016 low-hydrogen electrodes are used.

After tins of these rods have been opened, they are stored in a low-temperature oven until the rods are used, to keep coatings free of moisture absorption. Elimination of preheating of the weldment saves much time and inconvenience and the welder works more comfortably, as he does not have to stand close to hot surfaces.

George Bain is District Engineer, Lincoln Electric Co., Cleveland, Ohio.

A TECHNIQUE FOR TUBE BRAZING

An interesting brazing method for structural joints in steel tubing, which has been developed by the Elyria Welding Service of Elyria, Ohio, utilizes bronze beads for filler metal and applies the brazing alloy from the inside. The principal application is in structural assemblies of tubing in the sizes used for furniture, etc.

When fabricating a tee-joint in tubing, the most economical way to prepare the stem member is a mechanical notch (see Fig. 1). To avoid the expense of very close tolerances on fit-up, a bronze brazing alloy is used because it will fill an appreciable gap and make a strong bond without the necessity for a perfectly snug fit all around. The problem is to produce a full, uniform fillet in the shortest possible time.

Basis of this inside brazing technique is (1) a jig on which is mounted a multiple-tip torch that heats the entire joint simultaneously, and (2) use of a flux-bearing flame to prevent oxidation and to avoid leaving scale or flux residue on the work. The jig holds the flange member of the tee horizontally and the stem is held vertically above it (see Fig. 2). Brazing heat is supplied from a standard oxyacetylene welding torch fitted with an adapter which holds six flame-descaling tips on copper tubing leads (see Fig. 3). The tips are arranged so as to distribute the heat evenly around the joint. An auxiliary tube with a small tip serves as a pilot light. Solenoids in the oxygen and acetylene lines hooked up with a snap switch turn the brazing flames on and off.

A dual fluxing system is part of the technique. First, acetylene from the tank passes through a flux-bearing unit on its way to the torch and picks up a controlled amount of flux. This assures that the proper amount of flux is being delivered to the brazing area whenever and for as long as the flame plays on it. Second, the notched end of the vertical tube is dipped into a saturated solution of boric acid just before assembly, providing flux for the inside area where the flame does not reach.

Brazing alloy in round bead form is obtained by running a $^1/_8$-in. bronze welding rod through a cold heading machine. A scoop is made by brazing a short length of round steel rod to a piece of tubing of slightly more than $^1/_8$-in. ID, closed at one end and just long enough to hold the required number of beads for a particular joint. For example, a tee-joint in 1 $^1/_4$ in., 18-gage tubing will require six $^1/_8$-in. beads, about the equivalent of $^3/_4$ in. of brazing rod of the same diameter.

When the assembly is secured in the jig, a scoopful of the bronze beads is poured into the vertical tube and the brazing flames are started. It doesn't matter whether the beads are distributed evenly on the two

Based on a story by the Gasflux Co., Mansfield, Ohio.

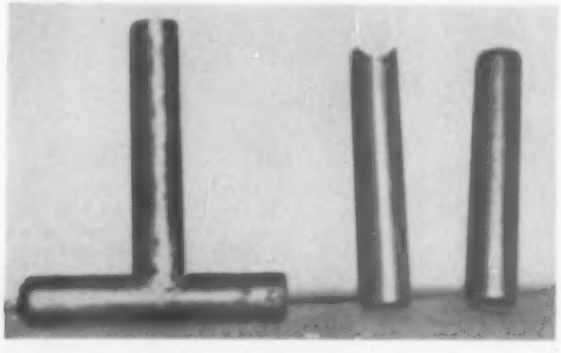


Fig. 1 Brazed Tee and component parts

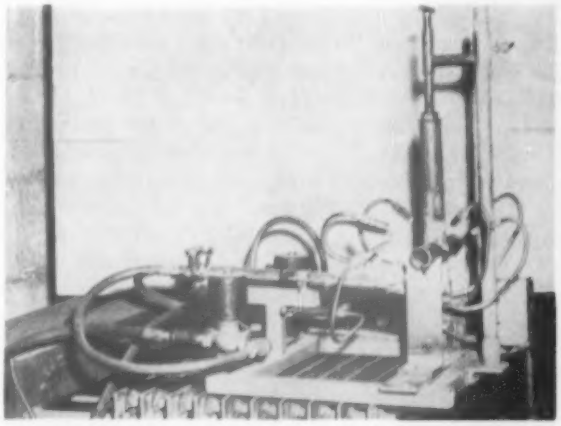


Fig. 2 Tube brazing jig with parts loaded, ready to braze

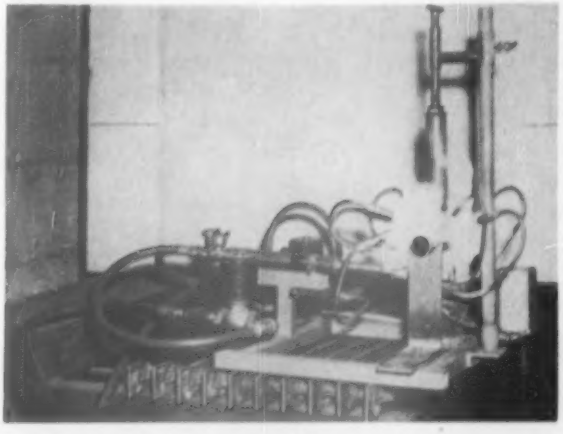


Fig. 3 Tee-joint in steel tube being brazed

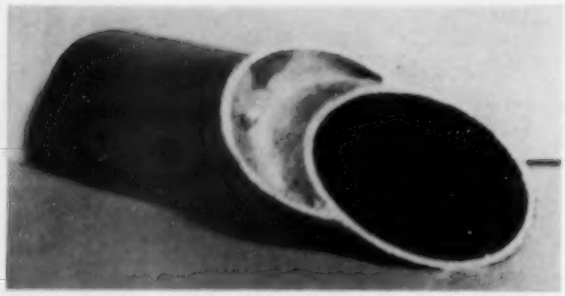


Fig. 4 Section of brazed joint, sawed diagonally to show complete penetration of brazing alloy

sides of the horizontal tube. Aided by capillarity, the molten bronze will flow through the joint wherever it has been wet with flux (see Fig. 4). The flux-bearing flame envelopes all of the joint on the outside, promotes complete filling of the joint and leaves the outside surface so clean that no grinding or brushing is needed before finishing. The operator shuts off the flame as soon as the brazing alloy starts to come through to the outside of the joint. Properly applied, this procedure is reported to make joints so strong that when tested to destruction they will fail by tearing of the base metal rather than opening the braze weld.

Fastest production with this process has been obtained by using two units mounted on a grating that spans the top of a rectangular tank partly filled with water. The operator loads one assembly while another is being brazed. Each assembly is dropped into the water immediately after brazing. Then it is dried and prepared for fitting into a larger assembly. Advantages noted in production are: (1) greater speed of brazing, (2) high strength of joint, (3) freedom from porosity, and (4) elimination of need for cleaning brazed surfaces before finishing.

PETROLEUM FILTERS ARE WELDED FOR X-RAY QUALITY

The Warner Lewis Co. of Tulsa, Okla., is using inert-gas metal-arc welding and submerged arc welding to fabricate a complete range of petroleum filters. Used on pipe lines, tank farms, fuel trucks, terminals, and tankers, where X-ray quality welds are required, these filters protect accessory equipment from contamination by water and dirt. The filters are available in any capacity from 10 gal. per min. purification rate, to 1200 gpm. In addition to the carbon-steel and aluminum-bronze plate from which these units are made, others have been fabricated of aluminum.

Inert-gas metal-arc welding is used to fabricate aluminum-bronze units on which the metal thickness ranges from $^3/_{16}$ in. for the drum section, to $^3/_4$ in. for the flange (see Fig. 1). No postweld treatment is necessary, and butt-welding speeds average 20 ipm. Submerged arc welding is used to fabricate the carbon-steel filters (see Fig. 2). These are generally larger than the aluminum-bronze units and are welded in one pass. By the use of submerged arc welding on carbon steel, fabricating operations have been speeded up 50%. A 9-ft longitudinal weld and a 75-in. circumferential weld are made in the $^3/_8$-in. steel plate at an average speed of 28-ipm.

In inert-gas metal-arc welding, argon gas shields the weld zone from the injurious affects of the atmosphere. Using the submerged-arc welding process, the weld zone is protected by a blanket of granulated material, and there are no sparks or glare.

Based on a story by the Linde Air Products Co., New York, N. Y.

Fig. 1 Inert-gas metal-arc welding of $^3/_{16}$-in.-thick aluminum-bronze sections of a petroleum filter

Fig. 2 Submerged arc welding being used to make a 75-in. circumferential weld in a $^3/_8$-in.-thick steel filter drum

NEARLY 800 WELDED STEEL BRIDGES ERECTED IN NEW YORK STATE SINCE 1942

Since 1942 the Department of Public Works of the State of New York, Albany, N. Y., has designed and constructed approximately 800 steel bridges, all of which, with a few exceptions, have been welded. Typical examples are given in Figs. 1, 2 and 3. This is in addition to many reinforced concrete bridges.

The Department has been a pioneer in this country for welded bridge construction. For reasons of economy, increased public safety and pleasing appearance, welding has become the standard for deck highway bridges.

Significant progress in the field of welded steel railroad bridges is also indicated. The Department has just completed its first all-welded steel railroad bridge which has been in satisfactory use since December, 1954.

Fig. 1 New York State Thruway over New York State Route 5 and New York Central Railroad (Main Line), West of Herkimer in Herkimer County; 100% welded deck cantilever plate girder bridge, built in 1954. The bridge has six spans totaling 775 ft; one at 105 ft, one at 152 ft, two at 102 ft each and two at 157 ft each. This structure consists of two separate bridges alongside of each other, each bridge having one 49 ft roadway, one 4 ft mall and one 2 ft 6 in. catwalk

The impetus to welded design developed with the change from through-type to deck-type bridges. This latter type incorporating composite construction supplied safety, functional appearance and economy through welding design. Using the full section of steel members provides for efficient and economical use of material, since no reductions are necessary as with riveted structures.

In many cases, especially where continuous design is used, the over-all depth of the bridge deck can be reduced significantly. This not only provides for necessary headroom under the bridge, but effects

Based on a story by the Lincoln Electric Co., Cleveland, Ohio.

Fig. 2 New York State Thruway over Onondaga Lake Outlet in Onondaga County; 100% welded deck cantilever plate girder bridge, built in 1953. The three main spans total 450 ft, with two at 125 ft each and one at 200 ft; a 49-ft roadway with an 8-ft mall separating opposing traffic and two 2 ft 6 in. catwalks.

appreciable saving. The savings on welded steel bridges designed by the Department have proven to average from 15 to 20% both in steel and in cost over similar steel riveted structures. Of equal importance are the savings in the foundations and fills. Saving 1 ft in depth at the bottom of the usual fill, when extended on the bridge approaches which constitutes miles of highway, can mount to major proportions in saving in money.

Arc welding is used for shear connectors, shoes, additional cover plates to rolled sections, 100% welded girder fabrication, bracing stiffeners, splices, etc.

Fig. 3 New York State Thruway over the Erie Railroad and State Highway 59 in Suffern, Rockland County; 100% welded deck cantilever plate girder bridge, built on a 2000-ft radius curve in 1955. The six main spans total 797 ft; one at 92 ft, one at 234 ft, one at 99 ft and three at 124 ft each. This structure consists of two separate bridges alongside each other and each bridge has one 49-ft roadway and two 3 ft 8 in. catwalks

RESISTANCE BRAZING OF ARMATURE ASSEMBLIES

Red Bank Division of Bendix Aviation Corp. is a leading manufacturer of quality electrical products for aircraft.

Armatures manufactured by the resistance brazing process have ample safety factor to withstand the high mechanical stresses imposed by many military applications.

Red Bank Division has achieved exceptionally high reliability with armatures produced on the resistance brazing machine illustrated in Figs. 1 and 2. Rate of production is also increased 500% over methods previously employed.

A clip of copper alloy brazing material is slipped on the interior conductors at all joints around the periphery of the armature. A cylindrical gauge ring holds the ends of all conductors in alignment.

Application of brazing current heats the conductors and commutator riser, joining outer conductor to inner conductor and also inner conductor to commutator riser simultaneously. Brazing time is sufficiently short to limit the objectionable flow of heat to interior of commutator segment. Successive brazing operations take place automatically around circumference of armature.

This brazing machine is tooled with support pedestals, clamping collet and floating center in order to facilitate loading and automatic index sequence to complete the total brazing operation. A variety of armature types can be handled on the same machine.

Based on a story by the Taylor-Winfield Corp., Warren, Ohio.

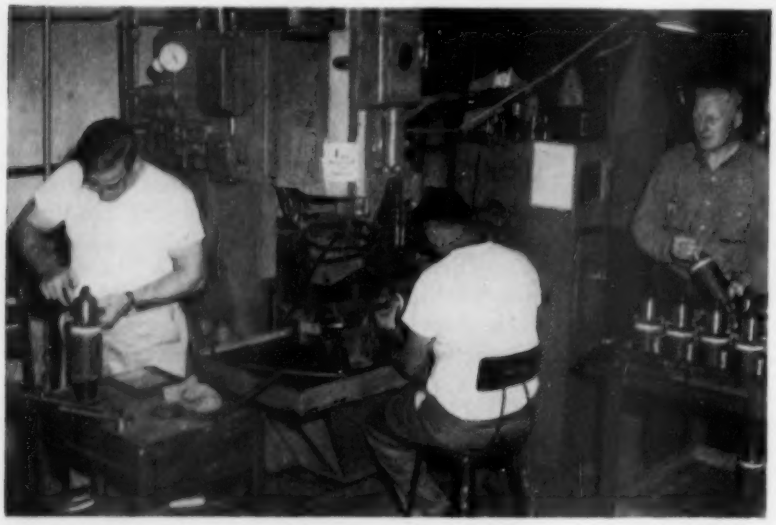


Fig. 1. Operator at left is inserting clips of brazing material around inner conductors of armature assembly, while operator in center is performing the actual machine brazing operation. Note special welding tooling used

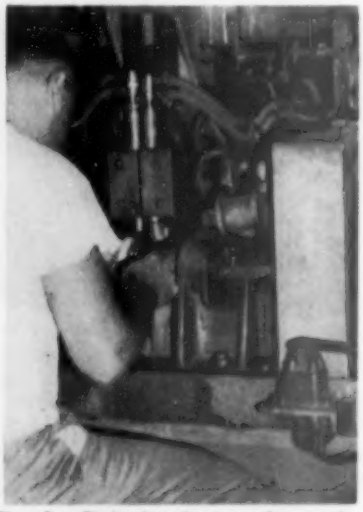


Fig. 2. Right hand view shows air-operated collet mechanism for clamping armature brazing electrode and secondary circuit contact

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Society News

Huge Assemblage of Welding Equipment, Top-Flight Technical Papers and Practical Conferences to Be Featured in Buffalo

A one-million dollar collection of welding equipment and accessories—the largest of its type ever gathered under one roof—will be waiting for visitors to the American Welding Society's fourth Welding Show in Buffalo, N. Y.

This huge assemblage of welding tools will include hundreds of items never shown publicly before. Visitors will have an opportunity to inspect all items, tinker with some, and operate others. About 750 experts from most leading suppliers in the field will be on hand to answer questions of visitors.

The three-day show will take place Wednesday, May 9, through Friday, May 11, during the same week as the Society's annual National Spring Meeting, which will occupy the entire week from May 7 through May 11.

Exhibits will be seen in Buffalo's modern Memorial Auditorium, while technical sessions will take place in the pleasant and comfortable atmosphere of the Hotel Statler.

A nontechnical Welding Conference, tried for the first time in Kansas City last year, will again be conducted. These sessions will be held in special rooms at Memorial Auditorium for the convenience of nonmembers of the Society and for others who do not customarily attend the Spring Meeting.

Two days will be devoted to the Conference. On the first day, the Conference topic will be "How to Solve Most Maintenance Welding Problems." On the second day of the Conference, the topic will be "How to Set Up and Conduct a Successful Welding Job Shop."

Although the Spring Meeting, the Show and the Conference, will be the three events occupying the major portion of the time of visitors, there will be many more important events, both social and business, for visitors.

A few of the more important ones include:

- The annual business meeting of the Society.
- Plant tours of Chevrolet Engine Division and Morrison Steel Products.
- Informal get-togethers, luncheons and dinners.
- The President's Reception.
- Ladies' activities.
- Sightseeing trips to Niagara Falls and Canada.
- Installation of new officers.

There will be many innovations at the 1956 Buffalo get-together. The Show itself will be larger, by far, than any previously held and the attendance is expected to break all records. Mere size, however, does not adequately indicate the new spirit. Many manufacturers will use the occasion to introduce new pieces of equipment and accessories and show their latest models. Thus, in a very real sense, the Show will become this year the one place where welding engineers can find every late development in the field.

Similarly, the Spring Meeting will not only provide one of the most varied and complete programs but will also offer several unprecedented sessions. These will include four sessions co-sponsored with the Metals Engineering Division of the American Society of Mechanical Engineers, and still another session co-sponsored by the Welding Committee of the Atomic Energy Commission.

Another feature will be the session on safety, health and fire prevention sponsored by the Society's Technical Activities Committee.

Obviously, too, there will be many new developments occasioned by the shifting of the Society's business meetings from Fall to Spring.

National Secretary J. G. Magrath urges all members to bear in mind the following:

1. Make hotel reservations promptly if you have not already done so.
2. Bring your associates. An event of the magnitude of the Buffalo meeting is an excellent one to bring to the attention of promising young men in the company.
3. Bring your family. Niagara Falls is one of the wonder spots in the world.
4. Sections should plan to travel together when possible. This can be arranged easily and adds to the pleasure of the trip.
5. Sections should call the show and meeting to the attention of companies in their area.

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TECHNICAL PAPERS SESSIONS

1956

AWS NATIONAL SPRING MEETING and ASME METALS ENGINEERING DIVISION CONFERENCE

MAY 7-11 • HOTEL STATLER, BUFFALO, N. Y.

REGISTRATION

Mezzanine Lounge, Hotel Statler

Sunday, May 6
3:00 P.M. to 6:00 P.M.
Monday, May 7
8:00 A.M. to 4:00 P.M.
Tuesday, May 8
8:00 A.M. to 4:00 P.M.
Wednesday, May 9
8:30 A.M. to 4:00 P.M.
Thursday, May 10
8:30 A.M. to 3:00 P.M.
Friday, May 11
8:30 A.M. to 12:30 P.M.

MAY 7, MONDAY MORNING

Ball Room—10:00 A.M.—Official Opening & Business Session

Address—*J. H. Humberstone, President, AWS*

Digest of the Technical Meeting Papers—*J. J. Chyle, 1st Vice-President, AWS*

European Welding Operation—Report and Open Discussion—*R. W. Clark, S. A. Greenberg and C. E. Jackson*

MAY 7, MONDAY AFTERNOON

Three Simultaneous Sessions

1. WELDABILITY AND RESEARCH

Empire State Room—2:00 P.M.

Chairman—CLARENCE E. JACKSON
Metals Research Laboratories
Vice-Chairman—R. E. SOMERS
Bethlehem Steel Co., Inc.

A. Evaluation of Weld Cracking Tests on Armor Steels
by S. WEISS, J. RAMSEY and H. UDIN, Massachusetts Institute of Technology

B. Some Dynamic Mechanical Properties of Heat-Treated Low-Alloy Weld Deposits (Ni-Mo-V 100XX)
by W. H. WOODING and E. H. FRANKS, Philadelphia Naval Shipyard

C. Impact Performance of Synthetically Reproduced Heat-Affected Zone Microstructures in T-1
by E. F. NIPPES, Rensselaer Polytechnic Institute, and C. R. SIBLEY, Air Reduction Research Labs.

2. GAS-SHIELDED WELDING

New York Room—2:00 P.M.

Chairman—H. E. MILLER
Carrier Corp.
Vice-Chairman—A. LESNEWICH
Air Reduction Co., Inc.

A. Metal Transfer Characteristics in Gas-Shielded Arc Welding
by HOWARD C. LUDWIG, Westinghouse Research Labs.

B. Argon-Hydrogen Mixtures for Tungsten-Arc Welding
by E. F. GORMAN and T. McELRATH, Linde Air Products Co.

C. New Power Sources for Metal-Arc Gas-Shielded Welding
by A. U. WELCH, General Electric Co.

3. WELDED STRUCTURES

Georgian Room—2:00 P.M.

Chairman—J. E. SOUTH
The Pennsylvania Railroad Co.
Vice-Chairman—GORDON CAPE
Dominion Bridge Co., Ltd.

A. Welded Joint Design for Economy in Structural Fabrication and Erection
by OMER BLODGETT, Lincoln Electric Co.

B. Welded Top Plate Beam-Column Connections
by CYRIL D. JENSEN, Lehigh University, and R. FORD PRAY III, Syracuse University

C. A New Concept in Fabrication and Launching of Vehicular Tunnel Tubes
by F. P. IAPALUCCI, C. J. ASCENZI and S. W. GEARHART, Jr., Baldwin-Lima-Hamilton Corp.

MAY 8, TUESDAY MORNING

Three Simultaneous Sessions

4. NUCLEAR REACTOR COMPONENTS

New York Room—9:30 A.M.

Sponsored by Welding Committee of Atomic Energy Commission

Chairman—F. W. DAVIS
Atomic Energy Commission
Vice-Chairman—R. A. NOLAND
Argonne National Laboratory

A. Fabrication of Homogeneous Reactor Test Vessel Assembly

by L. F. BLEDSOE, F. V. DALY, Newport News Shipbuilding & Drydock Co., and G. E. ELDER, W. R. GALL, E. C. MILLER, Union Carbide Nuclear Co.

B. Fusion Welding Zirconium for a Nuclear Reactor

by BRUCE L. BAIRD, North American Aviation, Inc.

C. Sodium Corrosion and Oxidation Resistance of High Temperature Brazing Alloys

by G. M. SLAUGHTER, C. F. LEITTEN, P. PATRIARCA, E. E. HOFFMAN and W. D. MANLY, Oak Ridge National Lab.

5. WELDABILITY AND RESEARCH

Empire State Room—9:30 A.M.

Chairman—DAVID SWAN
Metals Research Laboratories
Vice-Chairman—WILLIAM L. BURCH
Bell Aircraft Corp.

A. Investigation of Weld-Metal Cracking in High-Strength Steel—Part II

by ARTHUR LOWE, Jr., RAEMAN P. SOPHER, PERRY J. RIEPPEL, Battelle Memorial Institute

B. A Weld Cracking Susceptibility Test for Sheet Materials

by J. S. BOUDREAU, General Electric Co.

C. Fracture Behavior in the Slow Notch-Bend Test

by WILLIAM J. MURPHY and R. D. STOUT, Lehigh University

6. RESISTANCE WELDING

Georgian Room—9:30 A.M.

Chairman—W. J. WILSON
Kaiser Metal Products
Vice-Chairman—FRANK J. WEISS
Morrison Steel Products, Inc.

A. Electrical and Metallurgical Characteristics of Mash Seam Welds

by M. L. BEGEMAN and E. J. FUNK, University of Texas

B. Metal Gathering by the Resistance Heating Process

by W. F. HAESSLY, Taylor-Winfield Corp.

C. New Concepts for Control of Resistance Welding Machines

by WM. J. FARRELL and JULIUS SOLOMON, Sciaky Bros., Inc.

MAY 8, TUESDAY AFTERNOON

Three Simultaneous Sessions

7. WELDING OF DISSIMILAR METALS

New York Room—2:00 P.M.

Sponsored by the Metals Engineering Division of ASME

Chairman—W. E. TRUMPLER, JR.
Westinghouse Electric Corp.
Vice-Chairman—C. M. LOWELL
Worthington Corp.

A. Development of a Ferritic-Austenitic Weld Joint for Steam Plant Application, and Simulated Service Tests

by F. EBERLE and J. T. TUCKER, Babcock and Wilcox Co.

B. Butt Welding Austenitic Stainless Steel to Ferritic Steel in Cylindrical Shapes

by J. E. DONAHUE, Westinghouse Electric Corp.

C. Carbon Migration in Welded Joints at Elevated Temperature and Its Effect on Certain Mechanical Properties

by ROBERT J. CHRISTOFFEL, ROBERT M. CURRAN and JOHN E. CORR, General Electric Co.

8. SAFETY, HEALTH AND FIRE PREVENTION

Empire State Room—2:00 P.M.

Sponsored by Technical Activities Committee

Chairman—R. E. FERGUSON
Republic Steel Corp.
Vice-Chairman—H. F. REINHARD
Union Carbide and Carbon Corp.

A. Health Aspects of Welding

by B. L. VOSBURGH, M.D., General Electric Co.

B. Safety in Installation and Use of Welding Equipment

by BENJAMIN F. POSTMAN, Employers Mutual Liability Insurance Co.

C. Fire Prevention

by E. R. WALLACE, Eastman Kodak Company

D. A Plant Program for Plant Safety and Efficiency

(a) Development of Welding Safe Practices in General Motors

by ROBERT L. SNYDERS, General Motors Institute

(b) Application of Safe Welding Practices

by LEON J. ROSE, Fisher Body Div., General Motors Corp.

9. WELDING ELECTRODES

Georgian Room—2:00 P.M.

Chairman—LEE DE WALD
National Cylinder Gas Co.
Vice-Chairman—G. W. PLACE
American Bureau of Shipping

A. New Iron Powder Electrodes and Their Application

by ROBERT SHUTT, Lincoln Electric Co.

B. Effect of Moisture in the Coating of Low-Hydrogen Iron-Powder Electrodes

by D. C. SMITH, W. G. RINEHART and K. P. JOHANNES, Harnischfeger Corp.

C. Development of Filler Wires for Welding SAE 4130, 4140 and 4340 Steels

by H. W. MISHLER, R. P. SOPHER and P. J. RIEPPEL, Battelle Memorial Institute

MAY 9, WEDNESDAY MORNING

Three Simultaneous Sessions

10. TYPE 347 STAINLESS STEEL

New York Room—9:30 A.M.

Sponsored by Metals Engineering Division of ASME

Chairman—H. M. SOLDAN
Public Service Electric and Gas Co.

Vice-Chairman—D. H. CHRISTIE
Buffalo Forge Co.

A. Time and Temperature Dependence of Welded Joint Properties
by J. HEUSCHKEL, Westinghouse Research Labs.

B. Time-Temperature Effect on Properties of Weld Heat-Affected Zone in Type 347 Stainless Steel
by E. F. NIPPES, Rensselaer Polytechnic Institute, W. L. FLEISCHMANN and R. L. MEHAN, General Electric Co., B. SCHAAF, Westinghouse Electric Corp.

C. Some Considerations in the Welding of Austenitic Chromium-Nickel Stainless Steels
by O. R. CARPENTER and R. D. WYLIE, Babcock and Wilcox Co.

11. PIPING AND TUBING

Empire State Room—9:30 A.M.

Chairman—G. F. CADY, II
Cady Metal Fabricating Co.

Vice-Chairman—R. W. EMERSON
Pittsburgh Piping & Equipment Co.

A. Arc Welding of 2¼% Cr-1% Mo Alloy Steel Pipe
by JAY BLAND, Standard Oil Co. (Indiana)

B. Joining Tubes to Tube Sheets for Corrosive Radioactive Chemical Service
by W. R. SMITH, General Electric Co.

C. Economics of Welding in Small, Non-Critical Piping
by HERSCHEL A. SOSNIN, Tube Turns, Inc.

12. BRAZING AND SOLDERING

Georgian Room—9:30 A.M.

Chairman—W. J. VAN NATTEN
General Electric Co.

Vice-Chairman—W. L. BURKHARDT,
Air Reduction Sales Co.

A. Fatigue Strength of Silver Alloy Brazed Joints in Steel
by CHESTER H. CHATFIELD, Handy & Harman and SAM TOUR, Sam Tour & Co., Inc.

B. Physical Properties of Commercial Silver Copper Phosphorus Alloys
by KARL M. WEIGERT, Curtiss-Wright Corp.

C. Principles and New Developments of Tin-Zinc Alloys for Soldering Aluminum
by ARTHUR S. LAURENSON, Belmont Smelting and Refining Works, Inc.

MAY 9, WEDNESDAY AFTERNOON

Three Simultaneous Sessions

13. TESTS OF WELDS

New York Room—2:00 P.M.

Sponsored by Metals Engineering Division of ASME

Chairman—MARSHALL HOLT
Aluminum Company of America

Vice-Chairman—E. L. PAULSEN
Linde Air Products Co.

A. Correlation of Test Requirements with Characteristics of Welded Fabrication
by HELMUT THIELSCH, Grinnell Co.

B. Inspector's Interpretation of Results of Tests on Welds
by T. R. HARDIN, Hartford Steam Boiler Inspection & Insurance Co.

14. HIGH ALLOYS

Georgian Room—2:00 P.M.

Chairman—H. S. BLUMBERG
The M. W. Kellogg Co.

Vice-Chairman—SAMUEL CORICA
Harrrison Radiator Div., GMC

A. Rupture Properties of Inconel Weldments at 1400, 1600 and 1800° F
by DONALD A. SCOTT, The International Nickel Co. of Canada, Ltd.

B. Corrosion of Nickel-Chromium-Iron Alloys by Welding Slags
by GEORGE R. PEASE, The International Nickel Co., Inc.

C. Welding the Cupro-Nickels by the Inert-Gas-Shielded Arc Processes
by R. E. BURTH and LOWELL H. HAWTHORNE, Revere Copper and Brass, Inc.

15. WELDING AND CUTTING PROCESSES

Empire State Room—2:00 P.M.

Chairman—H. J. BICHSEL
Westinghouse Electric Corp.

Vice-Chairman—A. F. CHOUINARD
National Cylinder Gas Co.

A. Ultrasonic Welding
by J. BYRON JONES, Aeroprojects Inc., and JAMES J. POWERS, Jr., Pitman-Dunn Labs., Frankford Arsenal

B. Tungsten-Arc Cutting of Aluminum
by R. L. O'BRIEN, G. W. OYLER and J. MAIER, III, Linde Air Products Co.

C. Thermal Cutting of Aluminum, Stainless Steels and High Nickel Alloys
by EDWARD H. ROPER, Air Reduction Sales Co.

MAY 10, THURSDAY MORNING

Three Simultaneous Sessions

16. HIGHER WORKING STRESSES

Empire State Room—9:30 A.M.

Sponsored by Metals Engineering Division of ASME

Chairman—L. W. SMITH
Combustion Engineering Co., Inc.

Vice-Chairman—WILBERT A. KALK
Alco Products, Inc.

A. Evaluation of the Significance of Charpy Tests for Quenched and Tempered Steels
by P. P. PUZAK and W. S. PELLINI, Naval Research Laboratory

B. The Significance of Fatigue Data in Pressure Vessel Design
by T. J. DOLAN, University of Illinois

C. The Significance of the Tensile Test in Pressure Vessel Design
by W. E. COOPER, Knolls Atomic Lab. General Electric Co.

D. Considerations Affecting Future Pressure Vessel Codes
by J. J. MURPHY, C. R. SODERBERG, Jr., and D. B. ROSSHEIM, The M. W. Kellogg Co.

17. STAINLESS STEEL

Georgian Room—9:30 A.M.

Chairman—M. A. SCHEIL
A. O. Smith Corp.

Vice-Chairman—A. S. TUTTLE
The International Nickel Co. of Canada, Ltd.

A. Calculation of Ferrite Content of Stainless Steel Weld Metal
by W. T. DeLONG, G. A. OSTROM and E. R. SZUMACHOWSKI, The McKay Co.

B. Root Passes in Stainless Steel with New Inert-Arc Procedure
by EUGENE B. LaVELLE, L. H. RASMUSSEN and E. M. KUCHERA, General Electric Co.

C. Stress-Corrosion Cracking of Type 304 Austenitic Stainless Steel
by HUGH L. LOGAN and RICHARD J. SHERMAN, Jr., National Bureau of Standards

18. APPLICATIONS

New York Room—9:30 A.M.

Chairman—A. N. KUGLER
Air Reduction Sales Co.

Vice-Chairman—H. W. AINSWORTH
General Railway Signal Co.

A. Application of Pressure Welding to the Aircraft Industry
by ARNOLD P. LAGE, Menasco Mfg. Co.

B. How to Reclaim Plant and Machinery by Practical Welding Applications
by GEORGE GORDON MUSTED, Welding Engineer and Consultant

C. Nondestructive Testing of Welds
by WARREN J. McGONNAGLE, Argonne National Lab.

MAY 11, FRIDAY MORNING

Three Simultaneous Sessions

19. ALUMINUM

New York Room—9:30 A.M.

Chairman—LLOYD A. COOK
Kaiser Aluminum Co.

Vice-Chairman—K. T. LINQUIST
General Electric Co.

A. Large Scale Aluminum Fabrications
by STANLEY I. ROBERTS and O. P. CARDINAL, San Francisco Naval Shipyard

B. Arc Welding of High Strength Aluminum in Heavy Sections
by WILLIS G. GROTH and R. A. MATUSZESKI, ACF Industries, Inc.

C. Properties of Arc-Welded Joints Between Aluminum and Stainless Steel
by M. A. MILLER and E. W. MASON, Aluminum Company of America

20. PRESSURE VESSELS

Empire State Room—9:30 A.M.

Chairman—F. R. BAYSINGER
Alco Products, Inc.

Vice-Chairman—R. FLUCK
Bethlehem Steel Co.

A. Behavior of Welded Pressure Vessels in Agricultural Ammonia Service
by THOMAS J. DAWSON, Ingalls Shipbuilding Corp.

B. Investigation of Static and Fatigue Resistance of Model Pressure Vessels
by GEORGES WELTER and JULIEN DUBUC, École Polytechnique

C. Multi - Power Submerged - Arc Welding of Pressure Vessels and Pipe
by R. A. KUBLI and H. I. SHRUBSALL, Linde Air Products Co.

21. SURFACING

Georgian Room—9:30 A.M.

Chairman—H. S. AVERY
American Brake Shoe Co.

Vice-Chairman—D. D. CAMPBELL
Buffalo Forge Co.

A. Automatic Hardfacing Saves Pipe and Catalyst
by R. F. ARNOLDY, Texas Alloy Products Co.

B. Welded Overlay Rotating Bands
by FRANK W. HUSSEY and IRVING G. BETZ, Pitman-Dunn Laboratories, Frankford Arsenal

C. Comparative Properties of Electrodes for Arc-Welding Austenitic Manganese Steel
by H. F. REID, Jr., and W. L. LUTES, The McKay Co.

OTHER ACTIVITIES

MAY 7, MONDAY

10:00 A.M.—Annual Business Meeting in Ballroom of Hotel Statler

7:00 P.M.—Tables reserved for groups or individuals desiring to have dinner at the Chez Ami, a night club

MAY 8, TUESDAY

12:30 P.M.—Informal luncheon in Rendezvous Room of Hotel Statler Both ladies and men are cordially invited

6:00 P.M.—President's Reception in Ballroom of Hotel Statler—an opportunity to meet the National Officers, to renew acquaintances and to make new friends

8:00 P.M.—Tables reserved for groups or individuals desiring to have dinner at the Town Casino, a night club

MAY 9, WEDNESDAY

12:30 P.M.—Informal luncheon in Rendevous Room of Hotel Statler Both ladies and men are cordially invited

2:00 P.M.—Open meeting of National Nominating Committee in Buffalo Room of Hotel Statler

8:00 P.M.—Tables reserved for dinner at Hotel Sheraton Brock overlooking beautiful Niagara Falls

MAY 10, THURSDAY

10:00 A.M.—Board of Directors' Meeting in Hartford Room of Hotel Statler

12:30 P.M.—Sustaining Members' Luncheon in Buffalo Room of Hotel Statler

Informal luncheon in Rendezvous Room of Hotel Statler

6:00 P.M.—Buses will leave Hotel Statler for Buffalo Raceway where informal dinner will take place, to be followed by harness racing

WELDING CONFERENCES

MEMORIAL AUDITORIUM—LECTURE ROOM (AREA FLOOR)

WEDNESDAY, MAY 9, 2:00 P.M.

"*How to Solve Most Maintenance Welding Problems*," by L. D. Richardson, Eutectic Welding Alloys Corp.

Chairman: J. J. Jarms, Harnischfeger Corp.

THURSDAY, MAY 10, 2:00 P.M.

"*How to Set Up and Conduct a Successful Welding Job Shop*," by Lew Gilbert, Industry and Welding

Chairman: K. V. Lutz, All State Welding Alloys Co.

PLANT VISITS
MAY 9 and 10

Arrangements have been made for two very interesting plant tours during the AWS National Spring Meeting.

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On **Wednesday morning, 9:00 A.M., May 9,** a tour of Morrison Steel Products will be held. Persons attending this tour will have an opportunity to see the manufacture of warm air furnaces, overhead garage doors and truck bodies, together with other sheet steel parts including pressing of stampings, varied welding processes and final assembly operations including painting. Return to Hotel Statler by 12 noon.

•

On **Thursday morning, 9:00 A.M., May 10,** there will be a guided tour of the Chevrolet Motor Division in Buffalo. Here, members and guests will have an opportunity to see the entire manufacture, under the most modern conditions, of the 6 and 8 cylinder Chevrolet engines. It is expected that the tour will be concluded in time for every one to be back at the Hotel Statler by 12:30 P.M.

LADIES' PROGRAM
MAY 7–11

A varied and entertaining program has been arranged for the ladies during the 1956 Spring Meeting activity. On Tuesday, Wednesday and Thursday, May 8–10, coffee and sweet rolls, or equivalent, will be served the ladies each morning in the Los Angeles Room of the Hotel Statler. This Room has been reserved throughout the week for Ladies' Headquarters and Lounge.

On Monday, May 7, the attending ladies are invited to join with the ladies of the Niagara Frontier (Buffalo) Section in an informal get-together scheduled for the Los Angeles Room of the Hotel Statler.

A luncheon has been arranged for Tuesday, May 8, in the Rendezvous Room of the Hotel Statler—the men are invited to join with their ladies. Following luncheon, the ladies will have an opportunity to tour General Mills (manufacturers of cereal foods), and return to the Hotel Statler by approximately 4:00 P.M. In the evening, the President's Reception will take place in the Ballroom of the Statler and all ladies are most cordially invited to attend.

On Wednesday, May 9, the ladies will join with their men at luncheon in the Rendezvous Room of the Statler. After luncheon, there will be a trip to the Fort Erie Race Track, followed by shopping in Niagara Falls. In the evening, dinner will be served in the main dining room of the Sheraton Brock Hotel, overlooking beautiful Niagara Falls under colored lights. The men are invited to join with their ladies for dinner. Back at Hotel Statler at approximately 11:00 P.M.

On Thursday, May 10, the ladies will visit Oppenheim Collins where luncheon will be served, followed by a fashion show and card playing, with some time allowed for shopping. Cocktails and dinner will be served in the evening at the restaurant overlooking the Buffalo Raceway where harness racing may be enjoyed. Back to the Hotel Statler at approximately 11:30 P.M.

The "Breakfast at the Sheraton" radio program will be enjoyed by the ladies who attend breakfast at the Hotel Sheraton on Friday, May 11. A contest will take place during the program and many prizes will be awarded.

WELDING SHOW EXHIBITS AND DEMONSTRATIONS

MEMORIAL AUDITORIUM

Hours of the Exposition	***Wednesday, May 9***	***12:00 Noon to 10:00 P.M.***
	Thursday, May 10	***10:00 A.M. to 10:00 P.M.***
	Friday, May 11	***10:00 A.M. to 6:00 P.M.***

Admission by registration

HIGHLIGHTS OF EXHIBITS AT 1956 WELDING SHOW

MEMORIAL AUDITORIUM
BUFFALO, N.Y.

MAY 9–11

Acetogen Gas Co. **Booth No. 71**
Feature: Cylinder Acetogen Gas replaces cylinder acetylene. The carbide generator is eliminated by acetogen-city gas process. In both instances the savings are up to 50%.

Acro Welder Mfg. Co. Booth No. 210
Photographic and other display material on Acro built machinery such as standard and special purpose production welding equipment employing resistance and automatic shielded-arc welding processes

Air Reduction Sales Co.
Booth Nos. 52, 53, 54, 67, 68, 69
Live demonstrations of oxyacetylene brazing with Aircosil flux and gas cutting with No. 48 Duograph. Also, complete display of equipment for Aircomatic, Heliweld and Aircospot welding processes. Other features.

Alloy Rods Co. **Booth Nos. 79 & 80**
Demonstration of automatic and semiautomatic hard facing with Wear-O-Matic precision drawn hard-facing wire. Also, display and demonstration of several types of ferrous and nonferrous electrodes.

All-State Welding Alloys, Co., Inc.
Booth No. 35
Live demonstration of (1) two new silver-bearing solders on aluminum to dissimilar metals, and (2) automatic All-State "Jet Flux" system. Display of complete line of alloys and fluxes.

Aluminum Company of America
Booth Nos. 64 & 65
Feature: Alcoa's welding, brazing and soldering materials. Use of these joining processes illustrated with large pictures of typical applications and with sections of welded and brazed joints.

American Manganese Steel Div.
Booth Nos. 62 & 63
Display of complete line of Amsco automatic and semiautomatic hard-facing equipment, and manual manganese and hard-facing rod. Also, live demonstration of manganese and hard-facing materials.

American Platinum Works
Booth No. 96
An exhibit of low-temperature silver brazing with oxyacetylene torch and displays of several interesting new uses for this widely used joining method.

American Pullmax Co., Inc.
Booth No. 212
Display and operation of Pullmax model P-5 universal shearing and forming machine. Demonstration of new way for straight, circle, and inside-square cutting, as well as various forming operations.

Ampco Metal, Inc. **Booth No. 1**
Display of bronze Weldrod and resistance welding products. Also, new brazing rods, nickel aluminum bronze ac-dc electrodes and improved resistance welding holders.

Ampower Products Co. Booth No. 120
Principal feature: a newly designed portable spot welder. Model 55 has an electronic timing control and solenoid contactor. Also, display of production model 5403.

Arcair Co. **Booth No. 21**
Live demonstration of new Arcair automatic travel torch in action. Also, display of new manual models giving longer life and ease of handling.

Arcos Corp. **Booth Nos. 97 & 98**
Demonstration of new series of easy-to-use d-c reverse polarity electrodes for welding stainless aircraft and light gage materials as well as plate.

Aronson Machine Co. Booth No. 103
Display of new type of welding positioner featuring the Warner ICB Clutch System for use in latest welding processes; also 25 lb capacity bench positioner and turning rolls.

Balteau Electric Corp. Booth No. 208
Display of several units including (1) its amazingly lightweight industrial x-ray unit, the Baltospot, weighing 46 lb, penetration 140 kv, and (2) its new 260-kv portable equipment.

Banner Welder, Inc. **Booth No. 42**
Feature: A heavy duty spot-projection type welder and a special purpose welder. New literature will be distributed describing latest welder design.

Bay State Abrasive Products Co.
Booth Nos. 36 & 37
Fast, clean weld grinding with new Blue Flash BF disc-wheels will be demonstrated along with rest of Bay State's versatile group of portable grinding products.

Bernard Welding Equipment Co.
Booth No. 82
Display and live demonstration of "Shortstub" electrode holders, "Multi Pic" weld cleaning tools and "Pro Clamp" mechanical hands.

Brennen, Bucci & Weber **Booth No. 3**
Feature: 200-amp, portable arc welder; air-operated, automatic spot welder; 300-amp heavy duty industrial type welder; 50-kva press-type welder for spot welding aluminum.

Cam-Lok Division, Empire Products, Inc.
Booth No. 219
Display of neoprene insulated, waterproof, shockproof cable connections, portable molding kits, cable connectors, terminal connectors, cable lugs and electrode holders.

Cayuga Machine & Fabricating Co., Inc. **Booth Nos. 50 & 51**
Feature: Cayuga-matic high-speed indexing type motor frame welder in actual production. Also, display of several standard welding machines.

Champion Rivet Co. **Booth No. 116**
Feature: 25 years of progress in the manufacture of arc-welding electrodes with emphasis on new Champion line of iron-powder electrodes.

Diversey Corp. **Booth No. 61**
Demonstration of simplified and controlled method of cleaning and deoxidizing aluminum alloys to produce uniform

results and requirements established in Government Specification MilW-6860.

Dockson Corp. **Booth No. 123**

Feature: Dockson's new Model 55 "Economizer Regulator." It is the result of a need for a low-cost unit with exceptional sturdiness.

Easton Metal Powder Co. **Booth No. 9**

Display of various types of welding electrodes made from Easton Metal iron powder; blown-up pictures of Easton plant and powder manufacturing scenes; powder for cutting and scarfing.

Erico Products, Inc. **Booth No. 28**

Display of Caddy Arc Welding Accessory Division includes two new-type electrode holders plus many new features on current-type "B" electrode holder models.

Eutectic Welding Alloys Corp.
Booth No. 70

Feature: New 1956 Eutectic "low-temperature welding alloys" for electric-arc and oxyacetylene joining of cast iron, steel, stainless steel, aluminum, magnesium, copper, brass and bronze.

Federal Machine and Welder Co.
Booth No. 73

Display of combination seam and roll spot, three-phase aircraft welder incorporating new roll spot drive and improved air and flux reset systems.

Fibre-Metal Products Co.
Booth No. 99

Display of fiber, Fiberglas welding helmets; scarfing and special purpose masks; new all-plastic "Supergard" hats and caps and "Sologoggle." "Weld-prober" specimens extracted in live demonstration.

Frommelt Industries **Booth No. 111**

Major attraction will be approved protective products: "Spa-Fla" Spark Flash Portable Welding Shield and "Spa-Fla" with "Ray-Tex" for pipe-line welding.

Gas Appliance Service, Inc.
Booth No. 5

Live operation of small gas-fired "Utility" turntable brazing unit, demonstrating the silver brazing of small assemblies on a continuous basis.

General Electric Co.
Booth Nos. 47, 48 & 49

Feature: Redesigned display of both automatic and semiautomatic Fillerare. "Joe Magee" will demonstrate complete line of electrodes and accessories, including new LH-Z electrode.

Glendale Optical Co., Inc.
Booth No. 31

Display of latest in eye protection. Also, showing of coverall and eyecup welders and chippers goggles; plastic eye shields and face shields.

Goldsmith Bros. Smelting & Refining Co.
Booth No. 110

Feature: Silver brazing alloys (silver solders) conforming to all specifications. Complete service on silver-brazing alloy preforms. Fluxes for silver brazing, complete temperature range.

Handy & Harman
Booth Nos. 39 & 40

Live exhibit of high-production silver brazing job transplanted from a customer's shop. Also, display of samples brazed with Easy-Flo and Sil-fos alloys and Handy Flux.

Hard Face Welding & Machine Co., Inc. **Booth No. 204**

Display covering fabrication and/or repair of machine parts subject to wear or corrosion, such as piston rods, pump sleeves, etc. Leading brands of hard-facing alloys used.

Harnischfeger Corp.
Booth Nos. 88 & 89

Feature: New "dynamic balance" positioner, with the latest ac, dc. Also, display of ac-dc constant-voltage welders, low-hydrogen, iron-powder and stainless electrodes; and P & H hoist line.

Haynes Stellite Co.
Booth Nos. 76, 77, 78, 85, 86, 87

Exhibit of latest Haynes Stellite developments in hard-facing products and processes, including manual and mechanized methods of depositing cobalt-, iron-, and nickel-base alloys and tungsten carbide.

Heath Engineering Co. **Booth No. 17**

Feature: "Ultra-Graph" Machines in live demonstration of oxygen cutting techniques for automatic low-cost fabrication of accurate steel parts.

Hobart Brothers Co.
Booth Nos. 33 & 34

Display of latest improvements in automatic and semiautomatic arc-welding equipment. Also, showing of complete line of Hobart manual type welders.

Holger Andreasen, Inc. **Booth No. 19**

Display of "Andrex" portable x-ray equipment in capacities 160 kv, 200 kv and 260 kv; and "Androscope" portable x-ray diffraction stress analyzer, for measuring residual stress.

Industry & Welding **Booth No. 27**

Feature: Market analyses for the sale of welding, cutting and brazing products. Also, copies of "Industry & Welding" (monthly) and "Welding Illustrated" (quarterly) for general distribution.

International Nickel Co., Inc.
Booth Nos. 113, 114 & 115

Display and demonstration of new, recently developed welding products including Inco-Rod "A" electrodes for dissimilar metals, "135" Ni-o-nel electrodes, and 70/30 copper-nickel filler wires.

Jackson Products **Booth No. 205**

All-nylon "Adjust-o-Lok" headgear for Jackson welding helmets, new helmet styles and lens holders; safety cap and helmet, cap and goggle, hat and face shield.

K-G Equipment Co., Inc.
Booth No. 41

Display and demonstration of "On Guard" regulators, new "Flame Saw" for structural steel cutting, and latest welding, cutting and heating apparatus.

KSM Products, Inc. **Booth No. 224B**

Live demonstrations of stud welding. Also, display of KSM solid fluxed electric-arc welding studs, as well as accessory parts and equipment.

Kirkhof Manufacturing Corp.
Booth No. 226

Feature: Advance designs in small package type resistance welding transformers, and typical engineered controls for tying together welding machines and automation.

Lewis Welding & Engineering Corp.
Booth Nos. 230 & 231

Display and demonstration of newest model of Lewis track-type welding head manipulator, equipped with all the latest features.

Lincoln Electric Co. **Booth No. 72**

Demonstration of how semiautomatic, manual Lincolnweld equipment can be operated with a-c, d-c Idealarc machine. Also, new electrode developments and display of new automatic heads.

Linde Air Products Co.
Booth Nos. 76, 77, 78, 85, 86, 87

Live demonstration of Oxweld W-45, all-range oxyacetylene blowpipe; and Heliarc HW-17 air-cooled torch. Also, display of apparatus for automatic and manual inert-arc and submerged arc welding.

Liquid Carbonic Corp. **Booth No. 93**

Live demonstration of manual "MAG" CO_2 welding applications. Also, showing a complete line of gas welding and cutting equipment, arc welders and miscellaneous welding supplies.

McKay Co. **Booth No. 106**

Feature: New tubular hard-surfacing automatic wires and manual rods. Also, display of improved McKay "Comet-Arc" (E-6024), 716-IP (E-7016) and small diameter a-c, d-c stainless electrodes.

Metal & Thermit Corp.
Booth Nos. 74 & 85

Feature: New line of semiautomatic

welding machines and "Speedex HTS," a new low-hydrogen iron-powder electrode of the E-7016 type.

Metallizing Company of America
Booth No. 214

Feature: New Turbo-Jet metallizing machine—magnetic control over fastly increased feed ranges, combined with automatic feed-back system. Also, Mogulectric production metallizing machine—electrically driven.

Miller Electric Manufacturing Co.
Booth No. 66

Feature: a-c, d-c welder showing tungsten-arc welding of aluminum and stainless steel. Also, rectifier-type welder, horizontal rectifier unit gas drive, spot welders and tip remover.

Mills Welding Supply, Inc.
Booth No. 209

Feature: Display of Linde gas welding equipment, Lincoln arc welding equipment and accessories, and Worthington positioning equipment.

Modern Engineering Co.
Booth No. 201

Display of complete line of "Meco" oxyacetylene welding and cutting equipment, featuring new "Super Jiffy" soldering and brazing torch and double-stage regulators with flowmeters.

National Cylinder Gas Co.
Booth Nos. 44, 45, 46, 55, 56 & 57

Demonstration of new semiautomatic Dual Shield welding process. Also featured: oxyacetylene welding and cutting apparatus, arc-welding machines and Tube Turns Welding fittings.

National Torch Tip Co. Booth No. 101

Feature: New, complete line of quick preheating, fast starting, low oxygen consumption, fuel gas cutting tips for all torches. New line tip cleaners and torches.

OXO Welding Equipment Co.
Booth No. 218

Display of complete line of regulators featuring patented design and construction. Introduction of new "Oxomatic" flame-cutting apparatus. New automatic inert-gas and water control systems.

Page Steel and Wire Div.
Booth No. 38

Feature: Complete line of carbon-steel, low-alloy and stainless-steel submerged-arc and inert-gas welding wire, acetylene gas and metal spray wire.

Pandjiris Weldment Co. Booth No. 91

Display of a Pandjiris medium size positioner, a new line of small power turning rolls, a welding head manipulator, and an "Auto-Weld-Maton" machine.

Portomag Sales, Inc. Booth No. 25

Feature: Display of Porto-Magnetic line of plate clamps for flat and contoured surfaces; also, portable electromagnetic drill press.

Progressive Welder Sales Co.
Booth No. 26

Display and demonstration of standard press welder with roller head and instantaneous follow up; standard portable roll spot welder; standard portable pinch-type welding gun; associated components.

J. M. Ragle Industries Booth No. 216

Display of "Walloper," a combination center punch and cold chisel; also, sparklighters, drill kits, hose crimper, white metal rod, welders' caps, hose measuring machine and soapstone holders.

Reid-Avery Co., Inc. Booth No. 224A

Display of automatic welding equipment and complete line of welding electrodes and wire for all types of welding including submerged-arc and inert-arc processes.

Robotron Corp. Booth No. 92

Feature: High-speed, fully electronic, nonsynchronous welding control employing thyratron tubes and self-contained power supply for welder pilot-operated solenoid air valve.

Root, Neal & Co. Booth No. 102

Display of Arcos stainless-steel electrodes, Champion mild-steel electrodes, and Smith oxyacetylene equipment.

Ross Operating Valve Co.
Booth No. 225

Feature: Comet II, a lightweight aluminum valve available in single solenoid spring return and double solenoid mementary models. Conforms to JIC standards.

Sciaky Bros., Inc. Booth No. 100

Principal feature: exhibiting of application stories, sample parts, and resistance welding equipment.

Sellstrom Manufacturing Co.
Booth No. 206

Display of many items from complete line of eye and face protection including goggles, helmets, face shields, lenses, plates, respirators and gage glasses.

Sight Feed Generator Co.
Booth No. 227

Display and demonstration of "Rex-arc" completely engineered, packaged automatic welding machine. This machine will be complete in every detail and production welding will be done.

A. O. Smith Corp. Booth No. 90

Display of welding machines and complete line of A. O. Smith electrodes. Also, operating demonstration of carbon-dioxide welding processes.

Smith Welding Equipment Corp.
Booth Nos. 83 & 84

Demonstration of new series of oxy-acetylene cutting tips which provide high-speed cutting at low cost. Also, display of medium size Pipeliner welding and cutting torch.

Square D Company Booth No. 108

Feature: New "proximity" limit switch—no moving parts yet compatible with standard control systems. Also, display of operating resistance welder controls and new accessory items.

C. H. Stevens & Co., Inc.
Booth No. 122

Display of several models of the Weldline d-c welding controllers including the Multiman unit; demonstration of their flexibility and adaptability to various requirements.

Stoody Co.
Booth Nos. 220, 221, 222

Continuous demonstrations of semi-automatic welding, applying Stoody hard-facing alloys. An exhibit of various types of hard-faced equipment will also be made.

Sylvania Electric Products, Inc.
Booth No. 107

Feature: Use of Sylvania's four high-quality tungsten electrodes with copy and illustrations. Also, photographic dramatization of correct Sylvania rods and techniques for inert-gas welding.

Taylor-Winfield Corp.
Booth Nos. 94 & 95

Display of new models of resistance and arc-welding machines, standard welders and components, and photos illustrating special equipment for welding, brazing and hot-forming applications.

TEC Torch Co., Inc. Booth No. 112

Live demonstration of "Visuweld" water-cooled torches used in inert-gas tungsten-arc welding.

Tempil° Corp. Booth No. 207

Display of Tempil° temperature-indicating materials, demonstration of how Tempilsticks° indicate temperatures, and presentation of several techniques for determining temperatures in connection with welding operations.

Thomson Electric Welder Co.
Booth Nos. 118 & 119

Feature: New press welder equipped with "Cali-Matic" welding control which permits uninitiated to accurately set machine to any spot, projection or mash welding job.

Tweco Products Co. Booth No. 54

Display and demonstration of new 13½ oz, 300-amp, forged aluminum "Tweco-

Tong" holder and "Tweco-Lite" aluminum welding cable. Also, display of complete "Tweco" line.

Uniflex Cable Division, United Metal Craft Co. **Booth No. 12**

Display of basic cable designs for all types of resistance welding, be it portable gun welders or multiple welding fixtures.

Unique Turntable & Equipment Corp. **Booth No. 228B**

Feature: First display, anywhere, of "The Mity-Mite," an all-duty completely automatic combination of "turning roll, positioner, welding-head manipulator."

United Specialty Corp. **Booth No. 8**

Weldreel exhibit featuring several new models of arc-welding cable and twin-welding hose automatic retrieving reels.

United Wire & Supply Corp. **Booth No. 23**

Active display of all low-temperature silver and copper-phosphorous brazing alloys and fluxes, in all forms and shapes, featuring new "Phosons" and "Sil-Bonds."

Vacu-Blast Company, Inc. **Booth No. 121**

Display and demonstration of new "Utility Vacu-Blaster" with "Dual Gun" for cleaning the edges of plates before welding.

Velocity Power Tool Co. **Booth No. 20**

Feature: Introduction of "Safe-T-Lite Torch-O-Matic," a new acetylene torch featuring automatic finger-controlled ignition by spark from two pencil-sized dry-cell batteries.

Vickers Electric Division **Booth Nos. 202 & 203**

Feature: Live welding exhibition of "Controlarc" d-c welder, to demonstrate its many outstanding and exclusive features and characteristics. Optional equipment and some individual components of welder also shown.

Victor Equipment Company **Booth No. 228A**

Display of complete line of Victor flame welding and cutting equipment, high-pressure regulators, and hard-surfacing alloy rods and blasting nozzles. Also, live hard-surfacing demonstrations.

Wagner Manufacturing Co., Inc. **Booth No. 18**

Display of "Hi-Amp" line of welding accessories, including a "new look" in electrode holders, "Wrap Around" tip insulators, and high-heat resistance glass fiber insulation.

Wall Colmonoy Corp. **Booth Nos. 10 & 11**

Operating display of Colmonoy hard-facing rods, electrodes, Spraywelder and Sprayweld process. Complete presentation of stainless steel processing work; Nicrobraz; new line of high-temperature brazing alloys.

Webb Corp. **Booth Nos. 15 & 16**

Display of plate bending rolls, longitudinal seam welder, offset machines, assembly press and other equipment used in forming and fabrication of propane and butane tanks.

Welding Alloy Mfg. Co. **Booth No. 217**

Feature: Display of WALCO aluminum welding and brazing alloys, bronze, cable, lenses and cover glass, electrode holders; atmospheric air-acetylene and propane torches and equipment.

Welding Engineer Publications, Inc. **Booth No. 67**

Display of magazines and books on welding, cutting, etc., including "Welding Engineer," "The Welding Distributor" (new publication), "The Welding Encyclopedia," "Gas Welding Manual," and several others.

Weldit, Inc. **Booth No. 22**

Display of regular lines of Weldit welding and cutting equipment, featuring the new "50" Series Duo Trol and "55" Series single-stage regulators.

Welsh Manufacturing Co. **Booth No. 211**

Principal attraction: New metal and plastic square-shape spectacle goggles and new soft-side goggles manufactured by Welsh.

Weltronic Co. **Booth No. 117**

Display of inert-arc automatic welding control, three-phase control for commercial welding, time delays for standard and special machine sequencing, and N6HX high-speed gun welder control. Other products.

Westinghouse Electric Corp. **Booth Nos. 43, 58, 59 & 60**

Feature: Demonstration of Westing-arc process, a complete line of welders, accessories and electrodes. Also, demonstration of brazing with phos copper and phos silver.

Whitehead Metal Products Co., Inc. **Booth No. 229**

Feature: Various material samples of welding rod for aluminum, nickel, copper, stainless steel and their alloys. Also, demonstration of welding plastic materials.

Worthington Corp. **Booth No. 223**

Display of new line of Worthington automatic welding head manipulators, and showing of new power elevation which has been incorporated on all pedestal type positioners.

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A number of other organizations will also participate in the 1956 Welding Show. Unfortunately, however, the details of their exhibits were not available at the time that the preceding presentation was prepared and processed for publication.

The names of these companies are as follows:

Contour Marker Corp., Booth No. 81
Engwald Corp., Booth No. 213
C. B. Hunt & Son, Inc., Booth No. 24
Metal Removal Co., Booth No. 109

Tops in the Industry!

The Welding Journal is the world's most authoritative welding and allied process magazine; it has fully 2½ times the editorial content of any competing magazine; it is unequalled in coverage of welding engineering, research and application. If you have a product for the welding or allied industries, the Journal's pages will reach your market!

The AWS Welding Exposition

REVIEW OF ACTIVITIES AND STATEMENT OF POLICY BY THE AWS BOARD OF DIRECTORS

It is possible that no step undertaken by the American Welding Society has had a more far-reaching effect than the Society's institution of its own welding exposition. Society expositions have been conducted in Houston, June 1953, Buffalo, May 1954, and Kansas City, June 1955, and tentative plans have been formulated for expositions during the coming years in Buffalo, Philadelphia, and other cities. These expositions have been beneficial to your Society and to Industry. Exhibitors have shown their satisfaction by continued and increasing participation. Your management feels that the American Welding Society as a whole has additionally benefited through increased prestige and interest in membership.

The idea of the AWS sponsoring its own welding exposition had been suggested and considered for a number of years prior to taking formal action. Such action was decided upon by your Board of Directors in October 1952 after consultation with the Manufacturers Committee. An Exposition Committee was appointed, and assigned the task of producing and managing a welding exposition for the Spring of 1953. Needless to say, this assignment was a major one involving the engagement of an exposition manager, and the devotion of much of the time and energy of the Society's Secretary, Assistant Treasurer and involved members of its Headquarters Staff.

Concurrently with the decision to go ahead with the first American Welding Society exposition in Houston, an agreement was reached with the American Society for Metals, the sponsoring Society for the National Metal Congress and Exposition, to continue our existing arrangement with them for a period of five years with the option of terminating this agreement following the 1955 exposition. This agreement stipulated that the American Welding Society would not hold a Spring meeting and exposition in Chicago, Philadelphia, Cleveland, or subsequent to 1956 in Detroit, where the National Metal Congress and Expositions were to be held.

Your management has decided to terminate the arrangement carried on for many years of participating each Fall in the National Metal Congress and Exposition. This action is based upon the conclusion that the AWS should sponsor only one welding exposition each year and that the Society's interests will be best served by sponsoring its own welding exposition and holding its Annual Meeting at that time.

Following the successful expositions at Houston and Buffalo, a Five-Year Plan Committee was appointed as a Subcommittee of the Manufacturers Committee to study and make recommendations on desirable locations for future Society expositions. Experience has indicated that the following conditions should be met in the selection of suitable cities for the exposition:

1. A city located in an area of sufficient industrial potential to satisfy the requirements of a large number of welding exhibitors.
2. A city having exposition and hotel facilities suitable for accommodation of the equipment to be exhibited, and for housing of Society members and guests attending the exhibit and Society meetings.
3. A selected location so timed that exhibitor interest and attendance would not be diminished by other expositions held in the same location.
4. Assurance that the Society's interests be best served through increased prestige and interest in membership.

To accomplish the objectives it will be necessary as well as desirable to confine exhibits to those directly related to welding and allied processes. By so doing, it is believed that no rationing of space to the individual exhibitors need be imposed, nor will the exposition include segments of industry now being appropriately covered by other expositions.

It was the recommendation of the Five-Year Plan Committee that a pattern of exposition scheduling would, in future years, place welding expositions every other year in one of the larger industrial cities, and in the intervening years, in other cities. Such a pattern will, of course, be entirely subject to the availability and suitability of facilities, and the assurance of exposition potential to attract exhibit space buyers.

The requirements, based upon the objectives, impose limitations upon the number of suitable locations. Until such cities as Baltimore, Boston, Cincinnati and such others which do not now have suitable exposition hall facilities, construct such, they must be excluded from the AWS Exposition program.

At this time, the Society has not established the whole pattern of its national technical meetings. In addition to the technical meetings which will be held in conjunction with the Spring exposition, it may be compelled to hold a technical regional meeting in the Fall, unassociated with the exposition. If possible, such will be avoided as there are many advantages for consolidating all technical programs into one meeting each year. Our industry is growing and ways and means must be found to provide forums for the delivery and the hearing of practical and technical treatises of every character and of benefit to our membership and our industry, as well as publication for their recording and dissemination to all. Section meetings obviously provide a means of supplementing national meetings in this respect, and it is believed that the best policy will evolve with the continued growth of the welding industry and the American Welding Society.

Approved and Issued by the AWS Board of Directors
January 31, 1956

When a sheet metal electrode...

Has exceptionally smooth arc action... easy slag removal...

Yet operates on lower currents without sticking... with less burn through...

WHY

use anything but FLEETWELD 37 for thin gauge work

An E-6013 electrode made specially for sheet metal

FLEETWELD 37

to give you:

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than with conventional E-6013 electrodes

Specifications and Procedures are given in Weldirectory SB-1351. Write

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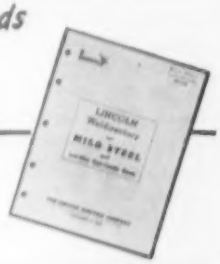

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"My men weld twice as fast with Airco Easyarc 12 rods"

The thick powdered metal coating on the Easyarc 12 electrode provides welding speeds that are about twice that of a conventional electrode, and results in excellent arc characteristics and ease of operation. Beads are very smooth and of good appearance. Slag removal is so much easier that definite savings in time are achieved. In welding mild steel, Easyarc 12 is excellent on build-up applications.

This is but one of many electrodes in Airco's complete line that also includes stainless steel, hard-facing, cast iron, general and special purpose electrodes. Send for free Airco Electrode Guide which will help you select the right electrode for your specific job. Request catalog 1318-WE.

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TAC TALKS

Welded Bridges

by J. E. South

As most of the readers know, the revised specifications for *Welded Highway and Railroad Bridges* have been printed and are ready for distribution. This new specification has been urgently needed and many of you have been impatiently awaiting its issuance. However, this has not been just a minor revision but is practically an entirely new specification. For this reason it has taken considerable time to prepare. Everyone who needed the old specification should obtain this revised specification before designing or fabricating any welded bridge.

The first requirement in revising the specification was to reach an agreeon the base metal. After several conferences with representatives of the steel producers, a steel specification was adopted. This steel was the same as is now covered under ASTM Specification A 373-54T.

Many engineers will ask, "What is wrong with A7 steel for welded structures?" In most cases there would be nothing wrong, and in the thinner sections most A7 steel would probably meet with the requirements of ASTM Specifications A 373-54T. It was the opinion of the committee that for welded bridges, subjected to cyclical loading, it was necessary to include in the specifications a limitation on the chemistry of the base metal. Without this limitation it is possible to obtain A7 steel that would be unsuitable for a welded bridge.

An addition to the specification which will be welcomed by many engineers is the coverage of submerged-arc welding. It is believed that the requirements in this specification cover the best practice of the industry as applied to welded bridges.

The committee intends that this specification will be revised as needed to keep it current with the developments in the welding field and to properly cover the main ingredients required for a good welded bridge: suitable materials, adequate design standards, the best welding techniques and proper inspection. Suggestions from the readers covering changes in the specifications will be welcomed.

J. E. South, is Chairman, AWS Conference Committee on Welded Bridges; Asst. Chief Engineer—Structures, Pennsylvania Railroad Co.

Sheren Elected to District Directorship

The Nominating Committee of AWS District No. 6 announces that, in the order of nomination and election, Keith Sheren has been elected to the office of District No. 6 Director and, concurrently, for a term of two years, member of the AWS National Board of Directors.

Mr. Sheren has been an active member of Detroit Section AWS, since 1942, in various committee activities and officer capacities as secretary-treasurer 1947–49 and chairman 1951–52.

He is an active member of Engineering Society of Detroit, Inc., a member of Henry Ford Trade School Alumni Association, and a number of social and fraternal organizations.

More recently he has been engaged in design applications and sales engineering with Swift Electric Welder Company and Taylor-Thompson Machinery Company since 1945.

Previously, 1926 to 1945, he was directly associated in automotive production manufacturing and equipment engineering activities, particularly welding, in various capacities since 1926 in body engineering, machine and tool construction, production equipment design and processing and project engineering with Ford Motor Company.

Nippes Made District Representative

Ernest F. Nippes, Rensselaer Polytechnic Institute, Troy, N. Y., has been elected by AWS District No. 1 to the office of District Representative on the 1957 National Nominating Committee. Dr. Nippes replaces Sidney Low who submitted his resignation due to his election to the office of District No. 1 Director and member of the National Board of Directors.

4th ANNUAL

SHOW

BUFFALO MEMORIAL AUDITORIUM

MAY 9, 10, 11

At the

WELDING SHOW

see the latest developments in Alcoa® Filler Metals and Fluxes for welding, brazing, soldering.

ALCOA—BOOTHS 64 & 65

New improved straight-length Alcoa Welding Rods.
Additional Alcoa alloys in spooled IG* electrodes.
Convenient new Alcoa packages . . . and many other new developments.
See you at Buffalo next month.

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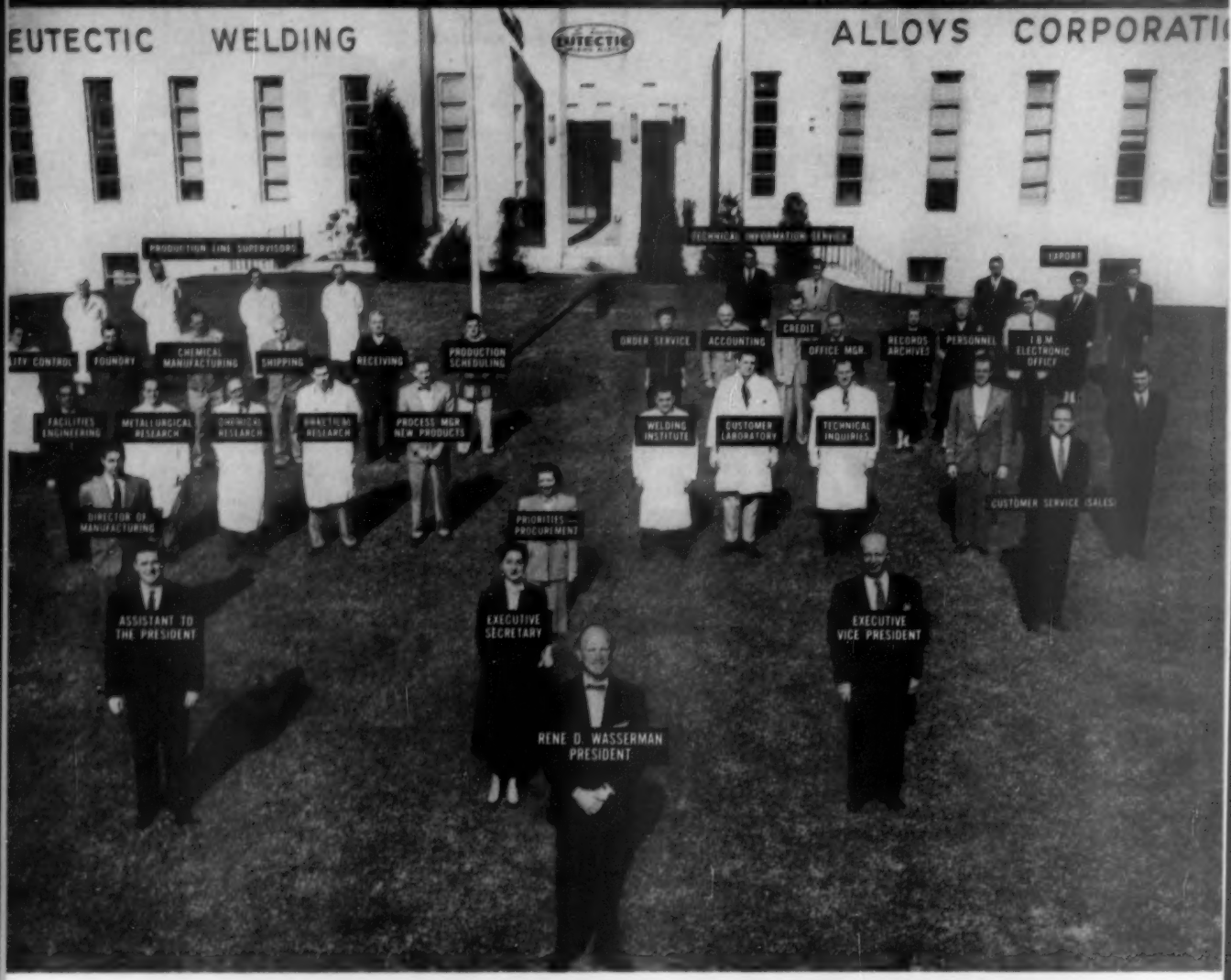

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Low Temperature EUTECTIC WELDING ALLOYS

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WELDING ALLOYS CORP.
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New Supporting Company Members Enrolled by AWS

Four additional organizations have recently become Supporting Company Members of the AMERICAN WELDING SOCIETY. They are as follows:

1. Fairbanks, Morse & Co.
   Lawton Ave.
   Beloit, Wis.
2. Farrar & Trefts Div.
   Adsco Industries, Inc.
   20 Milburn St.
   Buffalo 12, N. Y.
3. Sciaky Bros., Inc.
   Western Research Div.
   2311 Purdue Ave.
   Los Angeles 64, Calif.
4. Wagner Electric Corp.
   6400 Plymouth Ave.
   St. Louis 14, Mo.

The enrollments of Fairbanks, Morse & Co. and of Wagner Electric Corp. became effective on February 1st; those of Farrar & Trefts Div., and of Sciaky Bros., Inc., went into effect on March 1st.

Santa Clara Valley Welding Show and Clinic

The First Santa Clara Valley Welding Show and Clinic will be held in San Jose, Calif., on Friday and Saturday, April 27 and 28, 1956. The event, first of its kind in the Bay Region, will be held in the Engineering Building of San Jose State College, 8th and San Fernando Sts., San Jose. The show is being co-sponsored by the Santa Clara Valley Section of the American Welding Society and the Engineering Department of San Jose State College.

The show will be unique in its setting. The live exhibits will be placed among the most modern metallurgical and mechanical engineering equipment used at the college in training young engineers. Weld and metallurgical test equipment will be in operation. Exhibitors will show the latest in welding equipment. Several new processes will be demonstrated including inert-arc cutting of aluminum and other nonferrous metals.

There will be photographic displays of large welded projects, welded product displays of small objects and samples of welded jigs and fixtures. Welding and industrial type films will have intermittent projection in the comfortable soundproof lecture room.

All local welding suppliers will be exhibitors as well as many firms of national repute. Among early signed exhibitors are Linde Air Products Co., Metal & Thermit Corp., Victor Equipment Co., Stuart Oxygen Co., National Welding Equipment Co., Vacu-Blast Co., Birdsell Mfg. Co., Buck Mfg. Co., Tweco Products Co. and others.

All welding people including engineers, designers, students, instructors are invited to attend this free show. Admittance is by registration.

Lewis Welding Now a Sustaining Member

The Lewis Welding & Engineering Corp., is the latest company to become a Sustaining Member of the AMERICAN WELDING SOCIETY. Organized in 1938 to specialize in the design and production of welded steel machinery and machine tool components, it now operates two autonomous manufacturing divisions in the Cleveland, Ohio, area.

The Welding Division, Bedford, Ohio, produces 1000 tons of weldments per month for leading crane, coal mining, press and machine tool builders, it frequently undertakes the initial design and development as well as the ultimate production. The plant is particularly well equipped and produces fabrications varying in size from a few pounds to more than 30 tons.

The Machine Division, Euclid, Ohio, specializes in the design and manufacture of special machinery, most usually in the automatic assembly or metal working fields. It also serves as an auxiliary facility for the final machining of the products of the Welding Division when such operations are required.

J. T. Lewis, Jr., president, has been designated as the Sustaining Member representative.

Mechanical Properties of Weldments

The AFS-AWS Joint Committee on Welding Iron Castings invites data or test reports upon the mechanical properties of gray iron weldments. Welds made with different filler metals are eligible. Manufacturers of welding rod or casting consumers who have made tests of this type are invited to submit their data to the chairman of the Mechanical Properties of Weldments Subcommittee, Mr. Sidney Low, Chapman Valve Manufacturing Co., Indian Orchard, Mass. If so desired, the source of information will be treated as confidential and not revealed.

The committee would also welcome any other data on welding iron castings such as test methods, metallography, etc.

Section News and Events

as reported to Catherine O'Leary

PLANT TOUR

Fort Wayne, Ind.—Eighty-five members and guests of the *Anthony Wayne* Section made a tour of the Dana Corp. plant on January 26. A very fine dinner was served in the plant cafeteria, after which the group sojourned to the reception room where the assistant plant manager spoke to them on the history of the plant and outlined how the management and the workers solve their problems cooperatively. The speaker also explained the new self-locking differential, and the method of hardening axles by the Tocco method. The group was then shown the new equipment for upsetting flanging axle tubes and were conducted through the rest of the plant where guides answered the many questions put to them by the members and guests.

WELDING PROBLEMS

Phoenix, Ariz.—Arthur J. Williams [illegible], welding research engineer and metallurgist at the Consolidated Western Steel Division of the United States Steel Corp., Los Angeles, was the guest speaker at the January 18 meeting of the *Arizona* Section held at the Hotel Westward Ho. There were 33 members present.

Mr. Williams serves as welding consultant and conducts research work on new welding processes and plant welding problems for the Welding Metallurgical Department. His investigations include development work on the 3 o'clock welding, vertical welding, and twin-arc welding of storage tanks. He has had extensive experience on the welding of stainless steel and aircraft steels, nickel, titanium, copper and special alloys such as Hastelloy B, Stainless W and T-1 Steels.

TESTING FOR WELDABILITY

So. Boston, Mass.—The regular monthly dinner meeting of the *Boston* Section was held on February 14 in the Westinghouse Apparatus Auditorium with an attendance of 112 at dinner and 125 at the meeting.

As a coffee feature, an excellent 16-mm sound color film entitled, "Bridging San Francisco Bay" was shown through the courtesy of the United States Steel Supply Co. Technical speaker was Dr. H. Udin [illegible], owner and director of Suburban Metallurgical Laboratory; formerly Professor of Metallurgy at M.I.T.

Dr. Udin discussed the different methods of determining the weldability of steels, the advantages and shortcomings of each.

POSITIONING FOR WELDING

Chicago, Ill.—The regular monthly dinner meeting of the *Chicago* Section was held on January 20. Some 60 members and guests were present at dinner held at Burke Restaurant and 95 members and guests were present at the technical meeting held in the Peoples' Gas Auditorium.

SECTION MEETING CALENDAR

APRIL 27 and 28

SANTA CLARA VALLEY Welding Show and Clinic. Engineering Building, San Jose State College, 8 and San Fernando Streets, San Jose, Calif.

MAY 3

NORTHERN NEW YORK Section, Schenectady, N. Y. Ladies Nite—Annual Meeting.

MAY 4

LEHIGH VALLEY Section, Bethlehem, Pa. Annual Meeting and Ladies Night.

NORTH CENTRAL OHIO Section, Lima, Ohio. Dinner, technical meeting, movie, featured speaker, question and answer period.

MAY 8

DAYTON Section. 6:30 p.m. Dinner. Delco Lodge, Dayton, Ohio. Welding Quiz Program. Chairman, Bob Appenzaller.

MAY 9

OKLAHOMA CITY Section. "Recent Developments in Rectifier Type Welders," by G. K. Willecke, Miller Electric Mfg. Co.

MAY 10

IOWA-ILLINOIS Section. 7:30 p.m. American Legion Club, Moline, Illinois. "Arc Welding Machines, AC and DC," by representative, Hobart Bros.

NORTHWEST Section. 6:30 p.m. Covered Wagon, Minneapolis, Minn. "Delightful Program" of "You Know What." Special program and movies. No technical program. Annual election of officers.

MAY 16

SOUTH FLORIDA Section, Miami, Fla. Annual Section Meeting with election of officers for 1956–57.

MAY 17

MAHONING VALLEY SECTION, Youngstown, Ohio. Plant visitation.

MAY 18

CHICAGO Section. People's Gas Auditorium, 122 S. Michigan Ave., Chicago, Ill. 7:30 p.m. "Predetermined Procedures and Standards for Production Welding," by Harold E. Baldwin, LeTourneau Westinghouse (Peoria).

HARTFORD Section. Election of Officers at Lighthouse Inn, New London, Conn.

MARYLAND Section. Engineers Club, 6 W. Fayette Street, Baltimore, Md. Installation of Officers. Banquet and Dance.

MAY 19

DETROIT Section. Latin Quarter, Detroit, Mich. Ladies Night Party. Dinner, entertainment, music, dancing, door prizes.

FOX VALLEY Section. Appleton Elks, Wisconsin. Social-Dinner, Installation of Officers and Dance.

MILWAUKEE Section. May Party.

MAY 21

ROCHESTER Section, Rochester, N. Y. Social Evening and Election of Officers.

MAY 22

NORTHWESTERN PENNSYLVANIA Section. Erie, Pa. Annual Business Meeting.

MAY 24

MADISON, WISCONSIN Section. Social Meeting.

Editor's Note: Notices to be published in any one given issue must reach Journal office prior to the first of the preceding month. Give full information concerning time, place, topic and speaker for meeting.

COLORADO SECTION ADDRESSED BY GREENBERG ON WELDING SAFETY

Part of the attentive audience that was present at the February 14 meeting of the Colorado Section. Horace Jackson, District No. 8 director, is shown in the foreground

Technical Secretary "Si" Greenberg shown in the midst of his talk

Featured speaker was A. K. Pandjiris [AWS], president of Pandjiris Weldment Co., St. Louis, Mo. Mr. Pandjiris' talk on positioning for welding was presented in a fashion that was easily understood. During his talk Mr. Pandjiris showed films showing the various phases and applications of the subject. After his formal talk, the speaker displayed some miniature working models of a boom welder, welding positioner and some macroetch samples of welds which were made by positioning.

HARD SURFACING

Chicago, Ill.—At the February 24 meeting of the *Chicago* Section, Harry V. Kough [AWS], of Coast Metals, Inc., spoke on the subject entitled, "Hard-Surfacing Materials."

Because of some unforeseen and unusual circumstances, it was impossible to have a slide projector and operator present to assist Mr. Kough in his presentation. Since the showing of slides played a predominant part in his lecture, it was very important that these facilities be at hand. However, in spite of his handicap, Mr. Kough presented his subject in a highly successful manner.

The evening proved to be one of the most interesting the Section has had, because of the excellent manner in which this presentation was made.

WELDING SAFETY

Denver, Colo.—Some 44 members and guests of the *Colorado* Section were present at the dinner meeting held in the Festival Room of the Oxford Hotel on February 14 to hear the Technical Secretary S. A. Greenberg give a talk on "Welding Safety." Among other things that Mr. Greenberg discussed was the fact that people do not take welding safety seriously enough. He brought out some other very good points that are easily overlooked—the necessity of having a safety engineer is very important; ventilation is also an important factor; maintenance by maintenance men; proper clothing is sometimes overlooked; and many other safety factors.

After his technical talk, Mr. Greenberg showed slides taken during his European tour. The talk and the slides were thoroughly enjoyed by all.

WELDED DESIGN

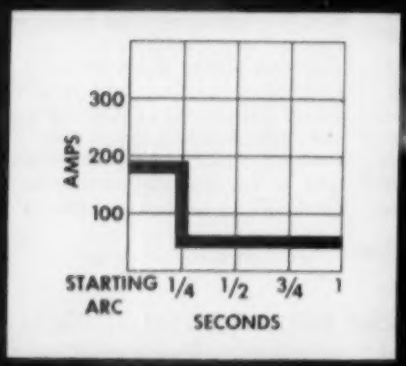
Detroit, Mich.—The regular meeting of the *Detroit* Section was held on Friday, February 10. Fred L. Plummer, director of engineering of the Hammond Iron Works and past president of the AWS, spoke on "Design for Welded Plate Fabrication." Those who attended were rewarded by a detailed discussion so ably presented that every phase of the problem seemed completely covered. The careful planning and correlation between shop preparation and field erection were described most vividly. To the layman, the outside of a storage tank presents a perfect picture of uniformity but the welding techniques vary from base to the top even as does the thickness of plate. Plate shaping and fitting methods, inspection, and the many other factors each received due attention.

At the dinner which preceded the auditorium meeting, Fred A. Huber, Jr., of the Detroit Hockey Club told the audience many things about professional hockey which were either new or incompletely understood before. He paid high tribute to the

HINKEL AND PLUMMER SPEAK BEFORE DETROIT SECTION

Jerry Hinkel speaking on welding electrode selection and application at a special technical meeting held on January 26

Fred L. Plummer shown with Chairman J. E. Rainey at the February 10 meeting. Mr. Plummer spoke on design for welded plate fabrication



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G-E MOTOR-GENERATOR WELDERS, are available in 200- and 300-amp sets. They feature a unique interactor, which practically eliminates popouts and voltage fluctuations.

NEW 200-AMP engine-drive welder, field-proven on construction and job-shop work, gives steady output, even above full load.

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1. NO FALSE STARTS. G-E automatic hot start provides that necessary extra surge of current which assures you of instant arc striking. Besides saving time, the hot-start furnishes extra penetration at the start of the weld—and reduces sticking.

2. ARCS ARE EASIER TO HANDLE, too. Popouts are practically eliminated because G.E. has made the normally stable a-c arc even more stable by the addition of special capacitors. These capacitors provide the equivalent of 5 additional open-circuit volts.

3. G.E.'s FINGER-TIP CONTROL gives you pinpoint accuracy of current with the moving-coil design. You don't have to "crank" the handle on a G-E welder to change current settings. It smoothly moves the primary coil on a finely-threaded, rubber-cushioned shaft—to give you stepless current control.

SEE FOR YOURSELF the operating advantages of the G-E a-c welder line. Ratings are available in 300-, 400-, and 500-amps . . . and 295 amps for general purpose welding. Just contact your nearby G-E Welding Distributor and ask for a demonstration. He's listed in the yellow pages of your phone book.

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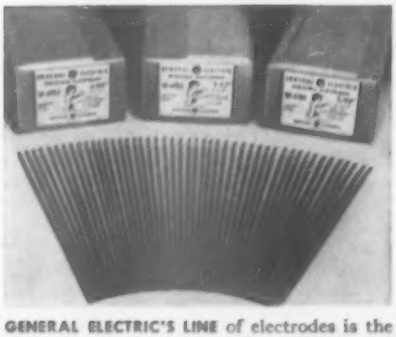
A G-E EXCLUSIVE on the new 300- and 400-amp d-c rectifier welders is full-time arc-force control, which gives you a forceful, easy-to-handle arc.



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- ☐ GEC-1333 G-E 200-amp Engine-drive Welder
- ☐ GED-2584 G-E Electrode Catalog

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WELDING ARCS NEWS

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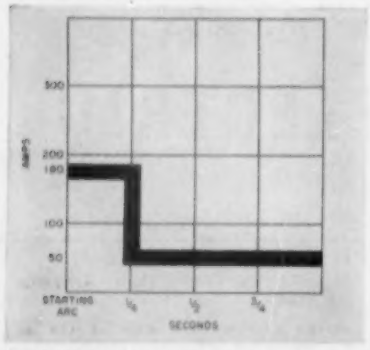
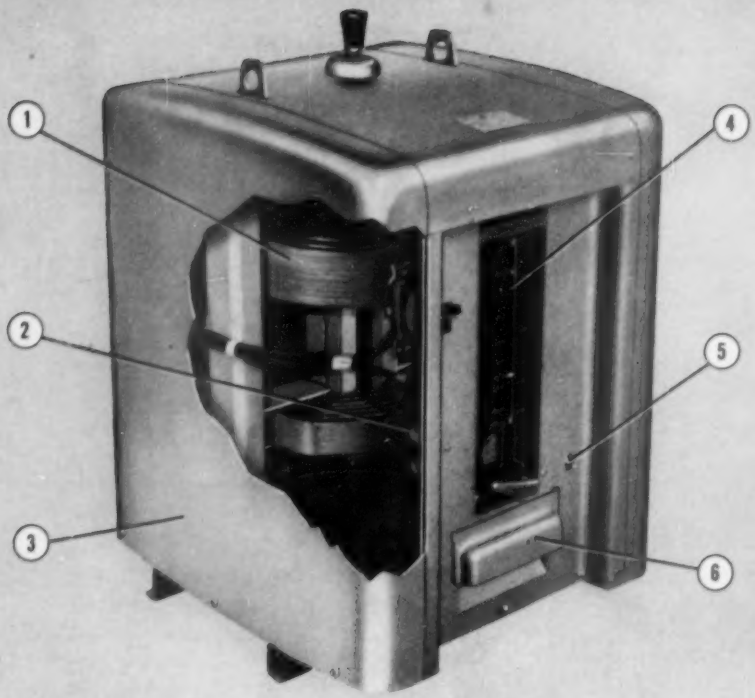


AUTOMATIC HOT-START gives extra surge of current when electrode touches work, reducing sticking, false starting. Welding is speeded, weld quality improved.



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1 MOVING-COIL DESIGN provides pinpoint accuracy in current settings and resettings. Settings can be made in an infinite number of steps over a wide current range.

2 ARC STABILIZERS—two arc stabilizing capacitors provide the equivalent of 5 open-circuit volts, to make the normally steady a-c arc even steadier.*

3 REMOVABLE SIDE COVERS come off with removal of just three screws. Routine maintenance and inspection are greatly simplified.

4 WIDE CURRENT RANGE spans 25 to 295 amps. Expanded lower end of range permits extremely accurate settings.

5 AUTOMATIC HOT-START assures instant arc striking by providing an extra surge of current on electrode contact. In addition, hot-start furnishes extra penetration at start of weld, reducing "sticking".*

6 UNIVERSAL BOLT-TYPE TERMINALS located at the base eliminate the nuisance and hazards of dangling leads.

For more information, contact your nearby G-E Welding Distributor (he's listed in the yellow pages of your phone book)—or write Section 712-2, General Electric Company, Schenectady, N. Y. for bulletin GEC-1305.

*Improved arc-performance features, available optionally.

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U. S. Olympic hockey team and said that their defeat of the Canadians for the first time marked a significant turning point in the growing rivalry with the good friends across the border. It was no discredit that the American boys lost to the Russian professionals.

Each year the Detroit Chapter holds special technical meetings of interest to a limited group of the membership. Nonmembers in the same field are welcomed. The first meeting of this type for this year featured welding electrode selection and application. Seventy-two members and guests heard a fine discussion by Jerry Hinkel AWS, of the Lincoln Electric Company of Cleveland, on Thursday, January 26. As was the regular meeting, this meeting was held in the Rackham Building, home of the Engineering Society of Detroit.

FIELD-ERECTED TANKS

Essex, Conn.—The night of February 16 saw a standout meeting of the *Hartford* Section. Once again the meeting was held at the famous old Griswold Inn and once again the Section had a fine program. After an excellent meal, Fred Plummer AWS literally took the audience around the world as he gave an excellent illustrated talk on the design and fabrication of field-erected storage tanks.

Mr. Plummer, who has twice been president of the AWS, is Engineering Director of the Hammond Iron Works in Warren, Pa. Educated at Case Institute and Ohio University, he holds membership in many Engineering Societies and has authored many books and papers.

His talk covered the design and erection of storage vessels, bins, stacks and pressure vessels using all types of automatic, manual and girth welding. His slides were also well received and were of interest not only to the men, but were also enjoyed by the ladies present.

DISSIMILAR ALLOYS

Houston, Tex.—The *Houston* Section held a meeting on February 22 in the Ben Milam Hotel, Houston, Tex., with 136 members and guests present.

Ken Spicer AWS, of the International Nickel Co., presented a talk on "The Welding of Dissimilar Alloys." The most active work on this subject has taken place in the last three or four years due to the demand for better metal combinations required in jet engines and nuclear reactors. Important aspects of welding dissimilar metals are proper selection of the welding process, filler material for the rods, properly executed welding procedure, and "welding predictability." A number of welding rods have been developed to take care of various combinations of metals. These rods are available on the market today. One weld was shown on a slide which was of particular interest. It showed a ring which was welded in this order—nickel to Monel to carbon steel to 347 stainless steel, to Inconel to K Monel—by the flash weld process. Mr. Spicer answered questions at the end of the session with facility.

The Houston Section was fortunate indeed to have had Mr. Spicer as a guest speaker.

IRON-POWDER ELECTRODES

Des Moines, Iowa—After a delicious buffet style dinner served at the Hotel Kirkwood, the January meeting of the *Iowa* Section held on the 19th, was opened with an address by Dick Lee AWS, vice-president in charge of research for the Alloy Rods Co., York, Pa. Mr. Lee spoke on the subject "Iron-Powder Low-Hydrogen Electrodes."

Mr. Lee pointed out that the iron-powder low-hydrogen electrodes combined the known advantages of the low-hydrogen type electrodes with the rapid deposition rate, easy arc starting, better arc stability, and higher currents attainable with the iron-powder coating. Porosity and underbead cracking are reduced or eliminated with the low-hydrogen coating.

Horizontal and vertical welds are deposited with very good surface appearance and internal quality. A welding project at one refinery had only seven and one-half feet of weld rejected out of one mile of low-hydrogen iron-powder weld deposited.

A drawback of conventional low-hydrogen rods is that they tend to overheat with slight excesses of welding current. The iron powder prevents the coating from overheating and thereby breaking down.

In conclusion, Mr. Lee pointed out how costs could be reduced with low-hydrogen iron-powder rods by greater deposition rate, less operator fatigue, less rework.

FEBRUARY MEETING OF AIRCRAFT AND ROCKETRY PANEL

Part of large crowd that attended the February 2 meeting of the Aircraft and Rocketry Panel of the Los Angeles Section

Guest speaker of the evening was George Foster, technical representative for the Air Reduction Pacific Co. His topic was "Tungsten Inert-Gas Spot Welding"

Enjoying the proceedings are (*left to right*) Charles Smith, vice-chairman; Francis McGinley, Chairman; and Dick Hayes, past chairman and director-at-large

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WELDING SAFETY

Kansas City, Mo.—A capacity crowd, some 80 in number, attended the *Kansas City* Section meeting on February 16, in the Frontier Room of the Golden Ox Restaurant, to hear Simon A. Greenberg, technical secretary of the AMERICAN WELDING SOCIETY. Mr. Greenberg's subject was "Safety in Welding" and the current interest in this subject was evident by the large attendance at the meeting. The Kansas City Section had as their guests members of ASM and ASSE.

Mr. Greenberg's talk covered a subject that everyone is interested in today and it is hoped that his talk will prevent potential welding hazards in the future.

A series of slides of welding operations in Europe, which Mr. Greenberg photographed when he traveled to Europe last year as a member of the government commission inspecting European welding, were also shown. They provoked a great deal of interest.

USE OF CARBON DIOXIDE

Hollis, L. I.—The technical speaker at the February meeting of the *Long Island* Section held at the Candlelight Restaurant, Manhasset, on February 9, was Julius Rubin of the Liquid Carbonic Corp. The subject was the "Use of Carbon Dioxide." The properties, effective use of CO_2, applications in mild and stainless-steel welding by the tungsten and consumable-electrode inert-gas-shielded processes were thoroughly covered.

INERT-ARC SPOT WELDING

Huntington Park, Calif.—The Aircraft and Rocketry Panel of the *Los Angeles* Section held its monthly dinner meeting on February 2 at the Elks Lodge, with approximately 105 members and guests present.

Speaker for the meeting was George Foster [illegible], technical representative for the Air Reduction Pacific Co., Los Angeles, whose subject was "Tungsten Inert-Gas Spot Welding." Mr. Foster with the use of slides described the various types of welds the process was adaptable to, procedures and equipment required. Also test procedures and test results on mild and stainless steel spotwelds made from one side of the joint. Included in the paper was a discussion of the several variables effecting the strength and consistency of the spot-welds. The paper was well presented and well received by all those present. Following Mr. Foster's paper, a film in color, procured through courtesy of the Lockheed Aircraft Company and titled "Guardian All," descriptive of what is being done and required by our civil defense to protect a free country, concluded the evening's program.

STUDENT'S NIGHT

Huntington Park, Calif.—About 240 members and guests of the *Los Angeles* Section were present for dinner and 456 attended the meeting and miniature welding show held on February 16 in the Huntington Park Elks Lodge. This meeting was called "Student's Night" in honor of the students in Southern California who are interested in welding. The schools participating in the evenings activities were UCLA, USC, Polytechnical Junior College, Los Angeles Trade Technical School, Fullerton Junior College, Canoga Park Junior College, El Camino Junior College, San Luis Obispo, Orange Coast College and Taft Junior College.

Russell Meredith was presented with the 1955 Achievement Award for his outstanding work in the research and development of the inert-gas tungsten-arc welding process.

Tom Fears, outstanding end of the Los Angeles "Rams," professional football team, gave a brief talk on so-called "Spring Training" for professional football players. He then exhibited a motion picture titled "The Highlights of the Rams' Games."

Panel moderator for the meeting was Dr. Allan Flanigan. The speakers were Frank Harkins [illegible], Solar Aircraft Co.; Mario Ochieano [illegible], Lockheed Aircraft Corp.; Harold Sharp [illegible], C. F. Braun and Co.; and A. M. Thompson [illegible], Fabriform Corp.

Mr. Harkins spoke on the inert-arc welding processes, stressing the usage of the processes and the quality of the work. Mr. Harkins said that over 200 million dollars are spent yearly throughout the country on inert-arc equipment.

Mr. Ochieano told of the use of and progress of resistance welding in the aircraft industry. He stated that the high efficiency of spot welding is shown in the Boeing Aircraft that has over 18,000 hr. of flying time and no sign of failures in any of the resistance welds.

Mr. Sharp, who is responsible for welding, tooling and methods at C. F. Braun and Co., spoke on his com-

"STUDENT'S NIGHT" HELD BY LOS ANGELES SECTION

Membership booth for "Student's Night" attended by Miss Frances Martin and Miss Anita Kirkland

Russell Meredith, on the left, accepting the 1955 Achievement Award from Section Chairman, F. V. McGinley

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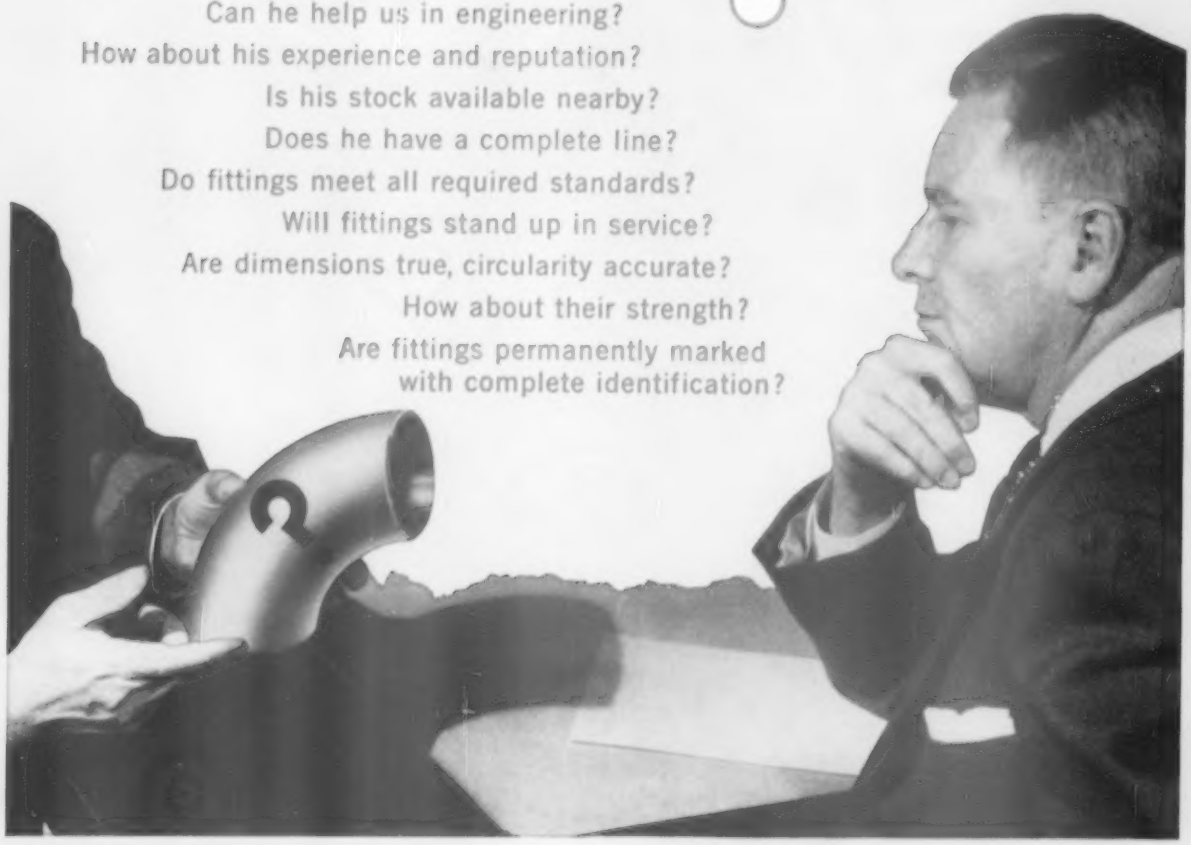

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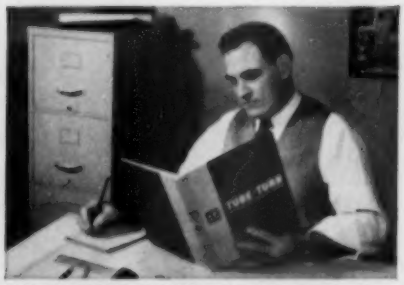

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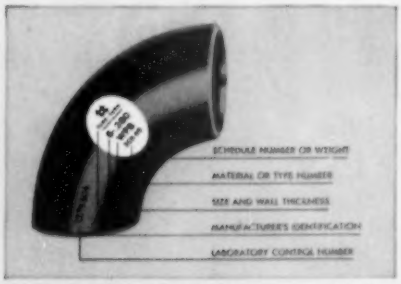

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pany's use of manual shielded-arc and submerged-arc welding processes, employed in fabricating the high-pressure steel vessels used throughout the oil and chemical industries. Mr. Sharp stated that over 200,000 tons of electrodes are used in a year by fabricators in this country.

Mr. Thompson told of the processes and problems involved in furnace brazing in industry and of the use of filler metals such as brass, silver, copper, aluminum and nickel chromes.

These short talks were followed by a question and answer period, after which a drawing was held for the visiting students. The prizes were five copies of the WELDING HANDBOOK and a football that had been autographed by members of the "Rams" team.

The meeting was closed at 10:20 P.M. The members and students then visited the miniature welding show where 31 exhibitors displayed their products. Coffee and donuts were served to those attending the show.

A membership booth was set up in the lobby where two hostesses passed out literature and accepted applications. This meeting and welding show was considered the most successful in the history of the Los Angeles Section.

WELDING SHOP MANAGEMENT

Madison, Wis.—The attendance at the February 23 meeting set a new record for the *Madison* Section. There were 78 members and guests present. Of these, 24 were members of the Engineering Institutes who were attending the University of Wisconsin for a three-day session on "Welding Applications," they capped the second day of their meeting by having dinner with the Section members and enjoying the fine presentation by the guest speaker, Lew Gilbert MWS, executive editor of "Industry & Welding."

Mr. Gilbert's interesting subject, "Shop Management for Better Welding," concerned itself more with the supervisory groups and dealt with the importance attached to weld inspection and welding tests being given to welders in search of "certification." Many fundamental steps were given. The over-all picture of Mr. Gilbert's address stressed the cooperation of management, supervisors and foremen in the selection of the proper method of handling any specific welding problem.

Dean Kurt F. Wendt of the University of Wisconsin was the coffee speaker. His interesting talk covered "The Importance of Engineering."

The Madison Section had a surprise pulled on them when Ted Jefferson MWS, editor of the *Welding Engineer* magazine, made an appearance. Howard Adkins, Madison Section chairman, extended the thanks and appreciation of the Section to Ted for his generosity this year in donating three one-year subscriptions to the *Welding Engineer* as door prize. These magazines are generally presented every other monthly meeting.

INSPECTION OF WELDS

Baltimore, Md.—The February meeting of the *Maryland* Section was held on Friday, February 17, at the Engineers Club in Baltimore.

The Technical speaker for the evening was Roger Clark MWS, manager in charge of Welding, Materials and Processes Laboratory, Large Steam Generator Department at General Electric Co., Schenectady, N. Y. Mr. Clark, a top authority on welding and weld inspection, used as his subject "Inspection of Welds." The speaker gave a systematic presentation for the need of inspection of weld. Mr. Clark's address was excellently presented and highly interesting.

The after-dinner talk was presented by Captain Sperry of the Air Reserve & Development Command of the Army Air Force. Captain Sperry used as his subject "Escape from Fast Moving Aircraft by Downward Ejection." This was an exceedingly interesting talk. The attendance was good at both the dinner and the technical session.

LADIES NIGHT

So. Bend, Ind.—The annual Ladies Night of the *Michiana* Section was held on January 19 at Russ Tavern. Entertainment, movies and flowers, plus a wonderful dinner, was the program for the evening. With the assistance of two of the Section members, Clinton Millikan, a noted magician, did a splendid job of entertaining the group. A fine movie on stainless steel was greatly appreciated by the ladies as it dealt with home appliances such as new stainless-steel kitchens.

VISIT TO A-C WORKS

Milwaukee, Wis.—Approximately 200 members of the *Milwaukee* Section visited the West Allis Works of Allis-Chalmers Manufacturing Co. on January 30, as part of the Section's Educational Program which was held on the four Monday evenings in January. 125 members attended each of the first three lectures.

One of the many interesting features seen by the members were the inspection facilities of the Betatron Laboratory where H. B. Norris, chief of nondestructive testing, explained the features of the company's 22-mv industrial betatron.

JOB SHOP WELDING

Milwaukee, Wis.—Sixty-eight members and guests of the *Milwaukee* Section were present at dinner and 85 at the technical meeting held on February 24 at the Ambassador Hotel.

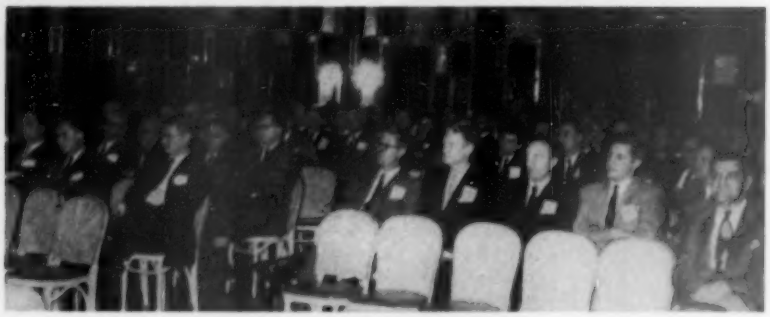
Coffee speaker was Ward Glaeser of

MILWAUKEE SECTION VISITS ALLIS-CHALMERS WORKS

A group of Milwaukee Section members viewing the Betatron Laboratory inspection facilities at the West Allis Works of Allis-Chalmers. H. B. Norris is explaining the features of 22-mv industrial betatron

BLUMBERG DISCUSSES PIPING MATERIALS BEFORE NEW JERSEY SECTION

Guest speaker H. S. Blumberg shown in the midst of his very interesting talk



This is a view of the large gathering in attendance at the February 21 meeting of New Jersey Section.

the Mutual Life Insurance Company of New York who gave a good talk on "Your Insurance Program."

Speaker at the technical session was Lew Gilbert AWS, executive editor of *Industry and Welding*, Cleveland, Ohio. Mr. Gilbert gave a nontechnical talk entitled "Slick Tricks for Job Shop Welders."

Three out-of-town visitors were also present at this meeting as follows: A. Smith, Philadelphia; Joe Simeon, Norfolk, Va.; and Dave Gerould, Dallas, Tex.

PIPING MATERIALS

Newark, N. J.—The *New Jersey* Section held their regular monthly meeting at the Essex House Hotel, Newark, N. J., on February 21.

Before 131 members and guests, the speaker of the evening, H. S. Blumberg AWS, chief metallurgist of M. W. Kellogg Co., of Jersey City, N. J., presented as his subject, "Piping Materials for Modern High Temperature-High Pressure Steam Power Plants." Mr. Blumberg discussed the requirements of materials for steam piping service, the alloy materials used and the welding of these materials. Mr. Blumberg reviewed in a general way the progress made in the past forty-five years in the manufacture of steam piping where the working temperature has risen from 500° F. to 1100° F., with future designs for working pressures and temperatures of 1200° and 3500 psi.

With the help of slides and charts, Mr. Blumberg described in detail the care used in the selection of materials for: (1) load-carrying capacity (creep rupture strength); (2) stability (lack of embrittlement), and (3) weldability.

At the conclusion of the talk, there followed a question and answer period conducted by H. L. Hoffman AWS, and the usual snack and get-together.

STRUCTURAL WELDING

New York, N. Y.—"Design and Construction of Welded Bridges and Buildings" was the subject of a paper presented to the *New York* Section on February 13, 1956. The paper was presented by Fred L. Plummer AWS, director of engineering of the Hammond Iron Works, Warren, Pa.

Mr. Plummer, who has been consulting engineer on many important bridge, building, dam, and foundation projects both here and abroad, presented a very interesting paper to a most attentive audience. Great strides have been made in replacing riveting with welded structures which in many cases can be prefabricated. Particularly in Europe, welded bridge and building construction have made great progress.

The speaker emphasized that there still are certain applications for riveting, however the method is gradually diminishing. There have been no failures as far as the welding is concerned, however research is being made so as to improve upon the steel now used, and the requirements for such steels are being set up.

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Mr. Plummer showed a number of slides and diagrams, all giving a very clear picture of the procedures.

Entertainment of the light variety was presented directly after the dinner.

The meeting was held at the Schwartz Restaurant, 54 Broad St., New York City, N. Y.

PRESSURE VESSELS

Niagara Falls, N. Y.—On January 26, the *Niagara Frontier* Section was pleased to have as its speaker E. C. Korten AWS, assistant chief engineer of the Boiler Division of the Hartford Steam Boiler Inspection & Insurance Co. Mr. Korten spoke on the subject "Fabrication and Welding of Pressure Vessels to ASME Code and Welder Qualification."

Mr. Korten has been associated with the Hartford company for 25 years and was previously connected with the Consolidated Edison Corp. and Thomas Murray, Inc. He is a graduate of Stevens Institute of Technology, holding a Mechanical Engineering degree, and is a member of the AMERICAN WELDING SOCIETY and the ASME. He is a member of the ASME Boiler and Pressure Vessel Committee, and Unfired Pressure Vessel, Power Boiler, and several other subcommittees.

Certainly this subject was one that proved interesting to industry in general around this area, as there were 81 in attendance at the dinner and at least 110 for the meeting.

Mr. Korten gave an explanation of the responsibilities and functions of those who write the Code, those who administer it, and those who use it. He also discussed steps to be taken in preparing to build welded pressure vessels under the Code requirements. This detail was explained simply and clearly. The important matters of Code welding, specifications, methods of testing, etc. were explained. The matter of shop and field inspection was also discussed.

It was the opinion of those who listened to this discussion that, within the time allotted, it was very well handled, and certainly the discussion was of great value to those who needed a little refreshing on the ASME Code and Welder Qualification Data.

PANEL QUIZ

Findley, Ohio—Eighty members and guests attended the third meeting of the season of the *North Central Ohio* Section held on Friday, November 4, 1955 at the Findlay Country Club, Findlay, Ohio.

The Meeting was a "Panel Quiz," with Panels selected from the eastern, central and western sections of the North Central Ohio Section. A prearranged group of questions was submitted to the Panels by the moderator and the judges graded the answers on the basis of the established answers previously removed from the AWS, WELDING HANDBOOK and THE WELDING JOURNAL.

Members of the eastern team were: S. W. McDonald—Captain; K. E. Showalter; R. B. Leiter; D. D. Smith; D. F. Eppley.

Members of the central team were: W. R. Edwards—Captain; H. F. Bates; W. C. Smith, Jr.; W. E. Phillians.

Members of the western team were: G. H. Howell—Captain; F. E. Donathan; R. A. Tarlton; J. D. Henne; R. Kruger.

Judges for the event were: J. E. Dipert; W. J. Corrigan; C. N. Walter.

Moderator was R. A. Ellison, Section Chairman.

The western team won, with the central team in second place.

WELDING METALLURGY

Erie, Pa.—Dr. G. E. Claussen AWS, of the Metals Research Lab., Linde Air Products Co., Niagara Falls, N. Y., was the featured speaker at the January 24 meeting of the *Northwestern Pennsylvania* Section. The meeting was held in the Kenyon Hotel. Dr. Claussen gave an excellent talk on the basic facts of the metallurgy of steel as it applies to welding.

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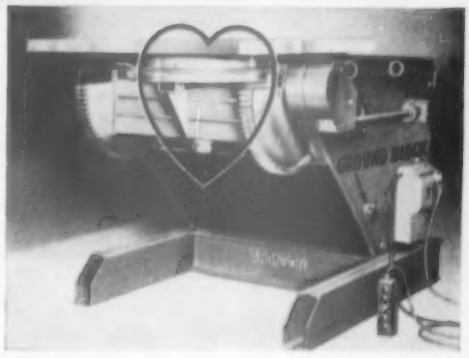

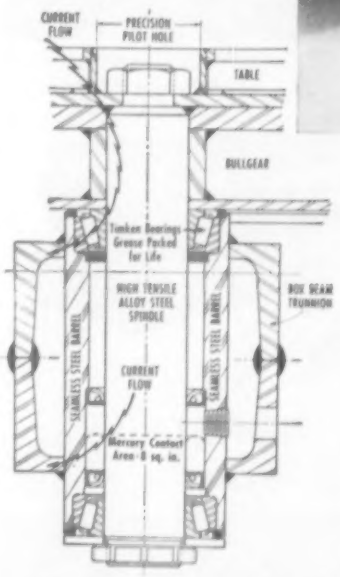

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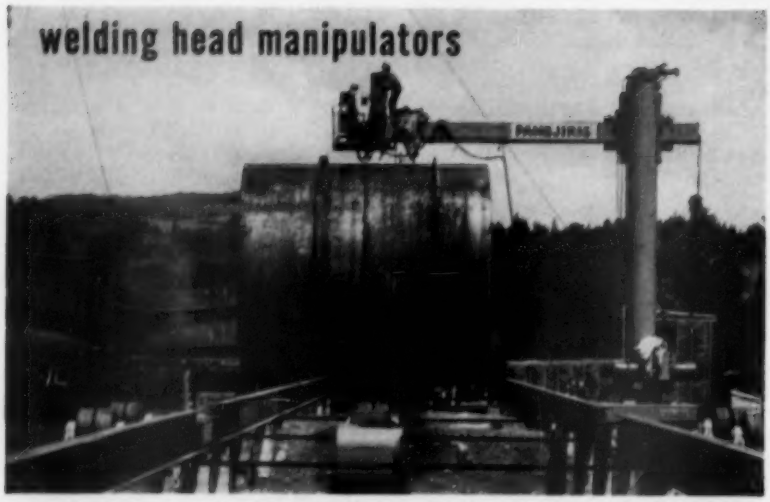
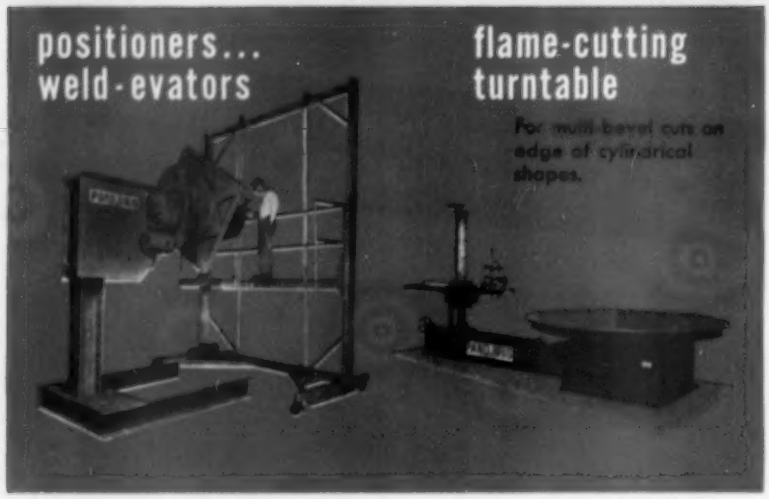
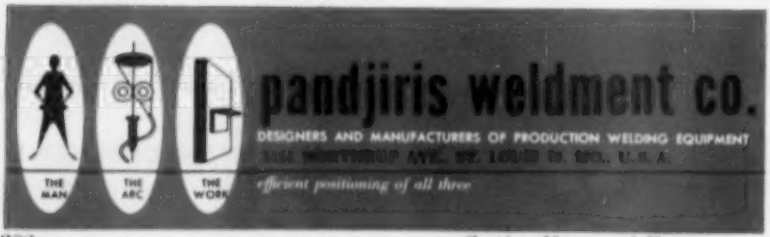






PLANT TOUR

Peoria, Ill.—A tour of the Engine Factory at Caterpillar Tractor Co., was the setting for the February 15 meeting of the *Peoria* Section.

There were 39 members and guests present for this tour, before which they were guests of Caterpillar Tractor Co., for dinner.

All present found the plant trip very interesting and worthwhile.

WELDED STRUCTURES

Philadelphia, Pa.—The regular monthly dinner meeting of the *Philadelphia* Section was held on Monday evening, February 20, at the Engineers Club.

The speaker of the evening was Van Rensselaer Saxe [illegible], consulting engineer of Baltimore, Md. Mr Saxe has spent many years in the design of welded steel structures and has been a strong advocate of welding over riveting for many years. He gave a very interesting discussion on general design, simplicity and economy of welded structures. Mr. Saxe has had a wide experience with riveted and reinforced concrete design before he became interested in welded structures and was able to draw upon this experience in dealing with his subject. He illustrated his talk with many slides which thoroughly covered the various connections made with welding compared to similar connections which are required with riveting. His background enabled him to answer without hesitation the many questions which were asked in the ensuing discussion.

PLANT TOUR

Richmond, Va.—The February meeting of the *Richmond* Section was held in the form of a plant tour of the Richmond Engineering Co., Inc. Forty-one members and guests assembled in the company cafeteria for dinner at 7:00 P.M., after which Vaughan E. Calder, Jr., plant manager, outlined the type of work done by his company, explaining the functions of the various work centers, the general lines of material flow through the plant, and the various equipment which is used.

The group was then divided into three equal parties, each under the guidance of a member who is employed by the Richmond Engineering Co. The parties entered the plant at five-minute intervals, and were guided through with brief stops for briefing in the various work centers.

Each party was in the plant for approximately forty-five minutes dur-

QUENCHED AND TEMPERED STEELS DISCUSSED BEFORE SHREVEPORT SECTION

The January 19 meeting of the Shreveport Section was devoted to a discussion of the suitability of quenched and tempered steels for pressure vessel construction. (Top) Picture of large crowd assembled for dinner. (Bottom) Speaker's table, with guest speaker Leon C. Bibber (wearing glasses and bow tie) shown seated at center

ing which time they witnessed the various stages of fabrication of the ferrous and nonferrous tanks and pressure vessels which form the bulk of the company's production.

DINNER-DANCE

Saginaw, Mich.—The annual Valentine dinner-dance of the *Saginaw Valley* Section was held at the Rolling Green Country Club in Saginaw on February 11. The party was attended by 165 couples. The ladies were furnished Valentine corsages. Many of the couples present won door prizes of fine merchandise. This party was a complete sellout and a great success.

ALLOY STEELS

St. Louis, Mo.—The February dinner meeting of the *St. Louis* Section was held on February 10 at the Unique Restaurant.

The principal speaker was N. C. Jessen [M], assistant superintendent, Boiler division, Babcock and Wilcox Co. Mr. Jessen's talk covered the procedures and techniques of welding alloy steel and high-pressure forgings. The talk was well illustrated by movies and slides.

WELDING OF PLASTICS

St. Louis, Mo.—A joint meeting of the *St. Louis* Section with the Engineers Club of St. Louis and the National Association of Corrosion Engineers was held on January 19 at the Engineers Club.

The principal speaker was Walter B. Meyer [M], president of St. Louis Metallizing Co.

Mr. Meyer's talk dealt with the physical and chemical properties of the various types of rigid plastic materials of construction, as well as their fabrication and applications.

Immediately following the talk, members of an NACE task force group acted as a panel in the question and answer session.

Mr. Meyer then presented an actual demonstration of the welding of plastic plate and pipe, after which the formal meeting was adjourned for refreshments and general discussion.

ROCKETRY MATERIALS

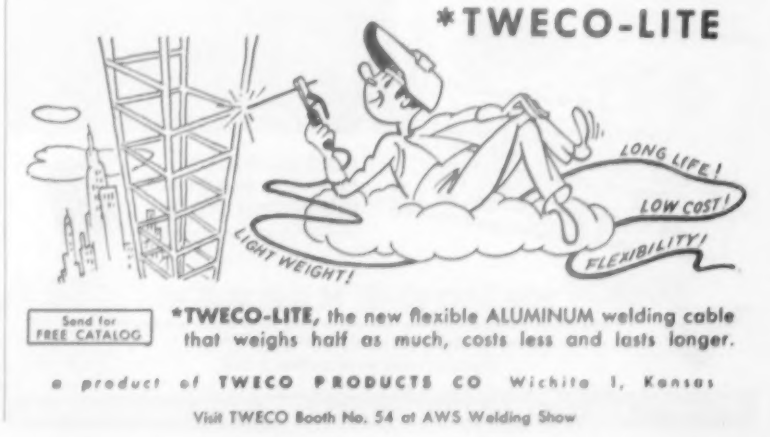
San Jose, Calif.—The *Santa Clara Valley* Section met at Wahl's Club on January 24, with 120 members in attendance.

The guest speaker of the evening was Francis H. Stevenson [M], production engineer-welding, Aerojet-General Corp. Mr. Stevenson's talk, extremely well-presented and received, covered the types of materials most commonly used in rocketry and the welding processes used to join these materials. Also, there was shown a short motion picture entitled, "The Sky Is No Limit."

The first Santa Clara Valley welding show and clinic will be held on April 27 and 28. Additional details will be found in the Society News section of this issue.

QUENCHED & TEMPERED STEELS

Shreveport, La.—Leon C. Bibber [M], of the United States Steel Corp., Applied Research Laboratory was the guest speaker at the January 19 meeting of the *Shreveport* Section held at the J. B. Beaird Co. cafeteria. Mr.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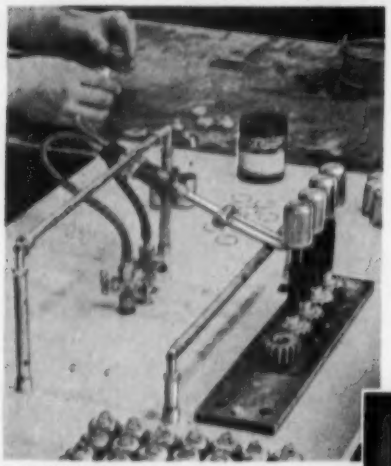

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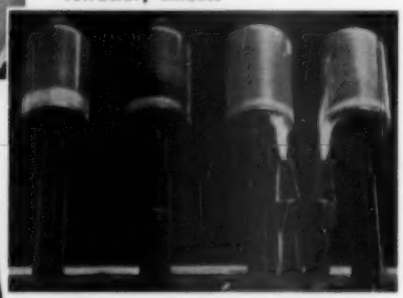

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There's no "...or equal" for EASY-FLO and SIL-FOS

Bibber used slides to show composition, stress-strain curves, transition curves of T-1 steel. Also, he discussed T-1 steel toughness which he defined as ability of a material to resist brittle facture.

Mr. Bibber discussed at length transition temperature which is the temperature at which a steel changes from a ductile to a brittle material. All steels, except austenitic (stainless) steel, have a transition temperature. The transition temperatures of many mild steels are within atmospheric temperatures; this, according to Mr. Bibber, is the cause of many failures where the steel is not stressed to above safe working range. Charpy keyhole notch tests of T-1 steel shows a transition temperature of −212° F.

Welding is a heating and quenching operation with resulting hardness in the heat-affected zone of hardenable steels, but causes no brittleness in T-1 steel.

If a material is tough and able to withstand small plastic deformation, then residual stresses and hardness are not detrimental to the material.

A. U. S. Steel movie, entitled "Operation T-1" was shown; it told the story of T-1 steel tanks that were built and tested to destruction under very low temperatures.

IRON-POWDER ELECTRODES

Miami, Fla.—The guest speaker at the February 15 meeting of the *South Florida* Section was Harry F. Reid [illegible], metallurgical engineer of the Technical Service Division, McKay Co., York, Pa. Mr. Reid gave a very interesting talk on iron-powder electrodes, outlining the history of the rod with a group of slides. A discussion on problems, advantages and disadvantages of this type electrode followed.

WELDING GLASS-LINED TANKS

Syracuse, N. Y.—The February dinner and technical meeting of the *Syracuse* Section was held on February 8 in the Hiawatha Room of the Hotel Onondaga.

The coffee speaker, Frank Kelley, executive secretary of the Council of Social Agencies of Syracuse and Onondaga County, gave an interesting and informative discourse on the operation and fund-raising problems of the United Social Agencies.

Mr. Kelley noted that there are at present 83 participating agencies in the Council and the financing of the operations is accomplished by using a deficit basis where in the budget

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Low hydrogen–iron powder electrodes for low alloy, high tensile steels, MUREX SPEEDEX HTS electrodes deposit more pounds of weld metal per hour than conventional electrodes. They are preferred for a variety of hard-to-weld metals, where welding speed and strength are important and underbead cracking must be minimized or eliminated.

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- SPEEDEX HTS produces porosity-free welds that will readily pass radiographic inspection.

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each year is actually the exact amount needed to pay for the previous year's activities.

Mr. J. D. Williams, chief production engineer of the Rheem Manufacturing Co., Sparrows Point plant in Maryland, whose subject, "Welding of Glass-Lined Water Tanks," gave a most informative and detailed explanation of the fabrication of the glass-lined tanks.

Mr. Williams traced the history of the water tank from the riveted range boiler in 1890 to the beginning of the all-welded hot water heater as we know it today. The hot water heater acceptance, after about 1938 by the plumbing industry, was brought about by an improvement in the arc-welding processes which produced a cheaper and stronger tank.

The present-day glass-lined tank which Rheem Manufacturing Co. markets is the result of five years of research and development.

Mr. Williams traced the production of the glass-lined tanks with a series of slides which graphically showed the manufacturing process from forming of the steel shells to the final assembly and crating of the tanks for shipment. A question and answer period followed.

AUTOMATION

Springfield, Mass.—The second and final meeting on Automation for the *Western Massachusetts* Section was held on February 14 at Blake's Restaurant. The first meeting was held on January 10.

There was a panel consisting of Sidney Low (moderator) of the Chapman Valve Manufacturing Co.; John Mortimer of the Whitlock Manufacturing Co.; and Frank Wallace of the Pratt and Whitney Aircraft.

The panel presented many points of interest for both sides of this timely subject; including how one goes about applying automation; what equipment is usually required; what type of equipment best lends itself to automation; how important are fixture design, inspection, maintenance of automatic equipment in automation.

The General Electric Co. supplied a colored movie on automation in various methods and forms. The entire meeting was very interesting and educational.

CARBON DIOXIDE WELDING

Grand Rapids, Mich.—The January meeting of the *Western Michigan* Section was held on Monday evening, January 23, at the Varsity Grille. Fifty-five were present for the usual well-prepared dinner and were joined by 6 more for the coffee talk and technical session.

The coffee talk was given by Paul Goebel, former mayor of Grand Rapids, who, up to two years ago, was a "Big Ten" referee. He related many of his experiences as a referee which were very interesting.

The technical talk was given by Robert Hill AWS, of the Westinghouse Corp., Detroit office. His talk on CO_2 welding was very interesting as evidenced by the many questions asked and the interest shown by many who stayed after the lecture to inquire further into the relatively new process of welding with CO_2.

QUIZ NITE

Grand Rapids, Mich.—The *Western Michigan* Section held its Annual Quiz Nite program on Monday evening, February 27, at the Varsity Grille in Grand Rapids. There were 55 present for the dinner and were joined by four more for the Quiz program.

Stuart Spice AWS, the planned moderator for the evening was taken ill and Fred Williams, also of the Buick Co., very ably replaced him. The panel was composed of Dudley Layman of Layman Welding Supply Co., in Grand Rapids; Wm. Qualls of the Goodrich Welding Equipment Co., in Hudsonville; Clarence Lankenau of the National Cylinder Gas Co., in Grand Rapids; Bob Kemp of the American Seating Co.; and Paul Thorne of the National Electric Welding Machine Co., in Bay City, Michigan.

Moderator Williams handled the questions very well, giving each man a chance to answer or to add to each question. Several suggestions were also brought forth from the audience. The panel did an excellent job in answering the questions.

After the meeting, each panel member and the moderator were presented with a ceramic ash try, with the compliments of the Section.

CONSTANT VOLTAGE WELDING

Worcester, Mass.—One of the best meetings of the season was held on February 6 by the *Worcester* Section, with an attendance of 97 at the Hickory House.

Technical speaker was John H. Headapohl AWS, automatic welding specialist for the Hobart Brothers Co., Troy, Ohio. His topic was "Con-

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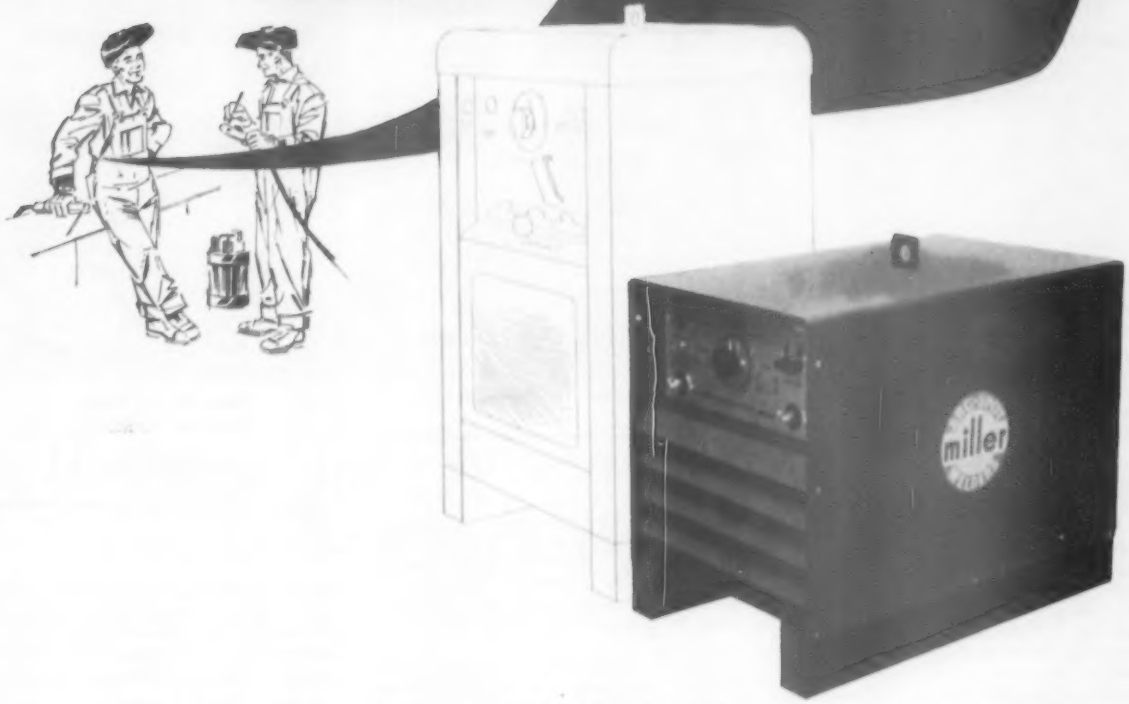
say, see the new **miller** *SRH low-boy?*



Where floor space is a problem — or where stacking and paralleling is indicated — the new Miller SRH LOWBOY is the engineered-to-your-needs answer! This dc rectifier type welder is available in three models with 60% duty ratings of 200, 300 and 400 amperes. Combining compactness with quiet operation, minimum arc blow, top electrical efficiency and waterproof construction, the LOWBOY is *another* Miller first that "figures."

Upright SR models to 600 amperes at 40 volts with 750 amperes maximum output; Duplex units up to 1200 amperes, 40 volts, 1500 amperes maximum.

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MILLER ARCWELD welding electrodes are worthy of the MILLER name and reputation. Ask your distributor for some . . . you'll like the job they do.

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stant Voltage, a Simplified Welding Tool."

Mr. Headapohl gave a very fine discourse on what can be accomplished by the use of constant voltage. The characteristics and simplicity of its use were described in full and were well illustrated.

EMPLOYMENT SERVICE BULLETIN

Positions Vacant

There is an urgent need for chemists, mathematicians, metallurgists, physicists, and electronic scientists in the Washington, D. C., area, the United States Civil Service Commission has announced. Vacancies are in various Federal agencies and pay salaries ranging from $4345 to $11,610 a year.

Further information and application forms may be obtained at many post offices throughout the country, or by writing to the U. S. Civil Service Commission, Washington 25, D. C. Applicants should ask for Announcement No. 46(B). Applications will be accepted by the Board of U. S. Civil Service Examiners, National Bureau of Standards, Washington 25, D. C., until further notice.

Services Available

A-685. Technical salesman in the welding supply and equipment field desires position with manufacturing company or dealer. Three years' sales experience, technical consultations, trouble shooting. Sound technical background of ten years in most phases of welding as welder and supervisor. Experienced in repairs of gas equipment. Well-rounded knowledge of office work. Prefer Greater New York and New Jersey area. Detailed information on request. 33 years of age, married, one child; two years' college education.

A-868. Welding Sales Engineer. Age 32; married; veteran. Fourteen years' welding and sales experience. Arc, gas, inert gas, submerged arc, domestic and export sales. Presently sales representative top Eastern Distributor. Trouble shooting; technical customer relations at top level. Will relocate or travel.

A-687. Graduate E.E. Engineer with 15 years' experience in all types of metals joining processes and equipment in a development and an administrative capacity. Possesses broad experience in (1) administrative ability, (2) budget and planning, (3) engineering and manufacturing background and practices, (4) national committee activities, (5) welding metallurgy, (6) technical papers and reports, (7) recruiting and assignment of personnel. Interested in administrative position in an engineering or manufacturing research activity. Indicate salary and location.

A-688. Chief Welding Engineer. Graduate engineer. Age 35, married, children. 15 years welding, welding supervisory, engineering, and engineering supervisory experience. Code work all materials and processes. West Coast only. $10,000 minimum.

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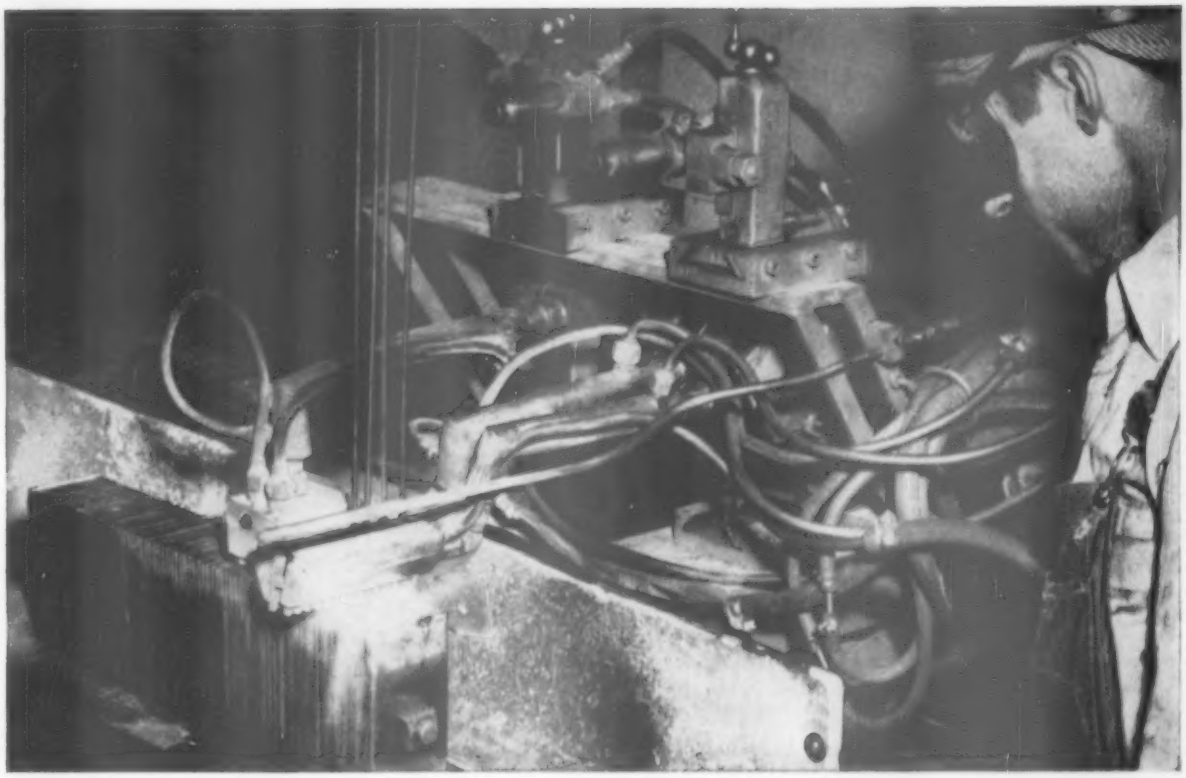

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Hard-facing with HAYSTELLITE tube rod has increased the life of hammers used in a heavy duty grinder by four times. The hammers rotate at from 3000 to 3600 revolutions per minute while pulverizing metal turnings, limestone, glass, mica, and other severe abrasives. They are hard-faced mechanically on a model 800 straight-line machine. 70 hammers are processed at a time, and 1000 hammers are hard-faced in a normal working day.

HAYSTELLITE rod, the hard-facing material used on the hammers, forms an extremely hard surface that has good resistance to impact. It produces a deposit consisting of sharp, irregularly shaped particles of cast tungsten carbide evenly distributed in a matrix of tough steel. The tungsten carbide particles resist abrasion, and the steel matrix cushions the effects of sudden shock.

There are 15 HAYNES hard-facing alloys . . . a wide selection that guarantees you the right rod at the right price for every wear problem. The HAYNES Hard-Facing Manual describes these alloys in detail, and outlines recommended procedures for applying them. We shall be happy to send you a copy upon request.

We also design and produce mechanized hard-facing equipment. For a description of the process and available equipment ask for "Mechanized Hard-Facing" Form 8564.

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New Members

Effective February 1, 1956

MEMBERSHIP CLASSIFICATION

A—Sustaining Member B—Member C—Associate Member

D—Student E—Honorary Member F—Life Member

Total National Membership February 1, 1956

Sustaining Members	*126*
Members	*5,367*
Associate Members	*5,658*
Student Members	*226*
Honorary Members	*10*
Life Members	*16*
Total	11,403

Support Your Society—Be Active!

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Sylvester, Robert (C)

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Turk, Martin (B)

CHATTANOOGA

Temple, John (B)

CHICAGO

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Drom, Wayne D. (C)
Dunn, Samuel S. (B)
Golzeris, Leo A. (C)
Lehrer, William M. (C)
Maybaum, John W. (C)
Peter, Fred H. (C)
Reid, Clarence W. (B)
Sheets, Earle (B)
Sheets, Jack D. (B)
Thompson, Earl (B)
Vogel, Edward J. (B)

CLEVELAND

French, Joel (B)
Hannah, James (C)
Haugh, E. S. (C)
Jarms, Jack J. (B)
Mortrud, A. T. (C)
Pytel, Gabriel P. (C)
Vukelich, Peter (C)
White, Eugene D. (C)
Zvanut, Albert J. (C)

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Rosenbach, Joseph (C)

COLUMBUS

Cochran, Eugene K. (B)
Johnston, Allen C. (C)
Pinyerd, Kenneth E. (C)

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Lavoorn, John D. (B)
Wells, William O. (B)

DAYTON

Brown, Raymond W. (B)
Makley, William A. (B)

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Blevins, Jack H. (B)
Blevins, James L. (B)
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Hilpert, Edgar L. (B)
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Simmons, Walter P. (B)
Vike, Elroy (B)
Welford, Albert C. (C)
White, Lauren C. (B)

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Kemm, H. E. (B)
Lechler, Helmuth C. (B)
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Siebers, Emmett A. (B)
Stoebers, Lloyd J. (C)
Ulrey, Bernard L. (C)
Voelker, David N. (B)
Waldron, J. G. (C)

HARTFORD

Chapman, Howard E. (B)
Gebalski, D. (B)
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Kendzia, J. E. (B)
Schneider, Robert W. (C)

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Bowman, J. E. (B)
Cowen, Henry H. (D)
Deavers, Troy H. (B)
Fritz, E. G. (B)
Hahn, Glen W. (D)
Jordan, R. F. (B)
Lanehart, William E. (C)
Monroe, Robert C. (D)
Olcott, Thomas M. (D)
Richards, B. A. (D)
Schrank, Elgin (B)
Scroggins, F. D. (C)
Stilley, F. D. (C)
Trevino, Rudy (B)
Wilson, Richard O. (D)

INDIANA

Ritzman, L. E. (B)

IOWA-ILLINOIS

Nelson, Harry C. (C)

KANSAS CITY

McMullen, Herbert S. (B)
Stucky, V. E. (B)

LEHIGH VALLEY

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Villard, William T. (B)

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Hedges-Blake, John C. (C)

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Ennis, Frank W. (B)
Lester, Robert W. (C)
Pomeroy, Rodney (B)
Porcaro, Frank J. (C)
Redman, Francis (C)
Rejo, John (C)
Tade, Paul E. (B)
Thayer, Ralph (C)
Tomich, Donald G. (B)
Trutta, Thomas P. (B)
Underwood, James F. (B)

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Rosencrance, Jack (B)
Shelton, J. F. (D)
Simpson, Loren J. (B)
Zick, Warren W. (B)

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Zarick, John (C)

MILWAUKEE

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Seaman, Frederick G. (C)
Soref, Edward (C)

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Ehernberger, John E. (B)
Haile, J. C. (C)
Moller, Clifford (C)

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Keep, Henry, Jr. (C)
Kunz, Harry R., Jr. (B)
Maren, Leo (B)
Mondelli, Charles S. (C)
Steel, George (B)
Walsh, John P. (B)

NEW ORLEANS

Luft, Edward F. (B)

NEW YORK

Ashfield, Walter (B)
Cantline, Peter, Jr. (C)
Chaft, Marc E. (B)
Garby, Charles (B)
Lewis, William R. (C)
Roberts, Howard A. (C)

NIAGARA FRONTIER

Anderson, Wallace J. (B)
Hayes, Matthew N. (B)
Kranz, Bernard (B)

NORTH CENTRAL OHIO

Guillerey, Wayne (B)
Tuttle, Robert D. (C)

NORTHEAST TENNESSEE

Dickison, Raymond R. (B)
Rowan, Roscoe C., Jr. (C)

NORTHWEST

McCann, Robert J. (C)

NORTHWESTERN PENNSYLVANIA

Donatucci, John (C)

PEORIA

Burdick, Robert G. (B)
Cheneler, Rocco (C)
Flynn, Thomas R. (B)
Gauch, Donald (C)
Thompson, Kenneth L. (C)

PHILADELPHIA

McLaughlin, Albert R. (B)
Sima, J. J. (C)

PITTSBURGH

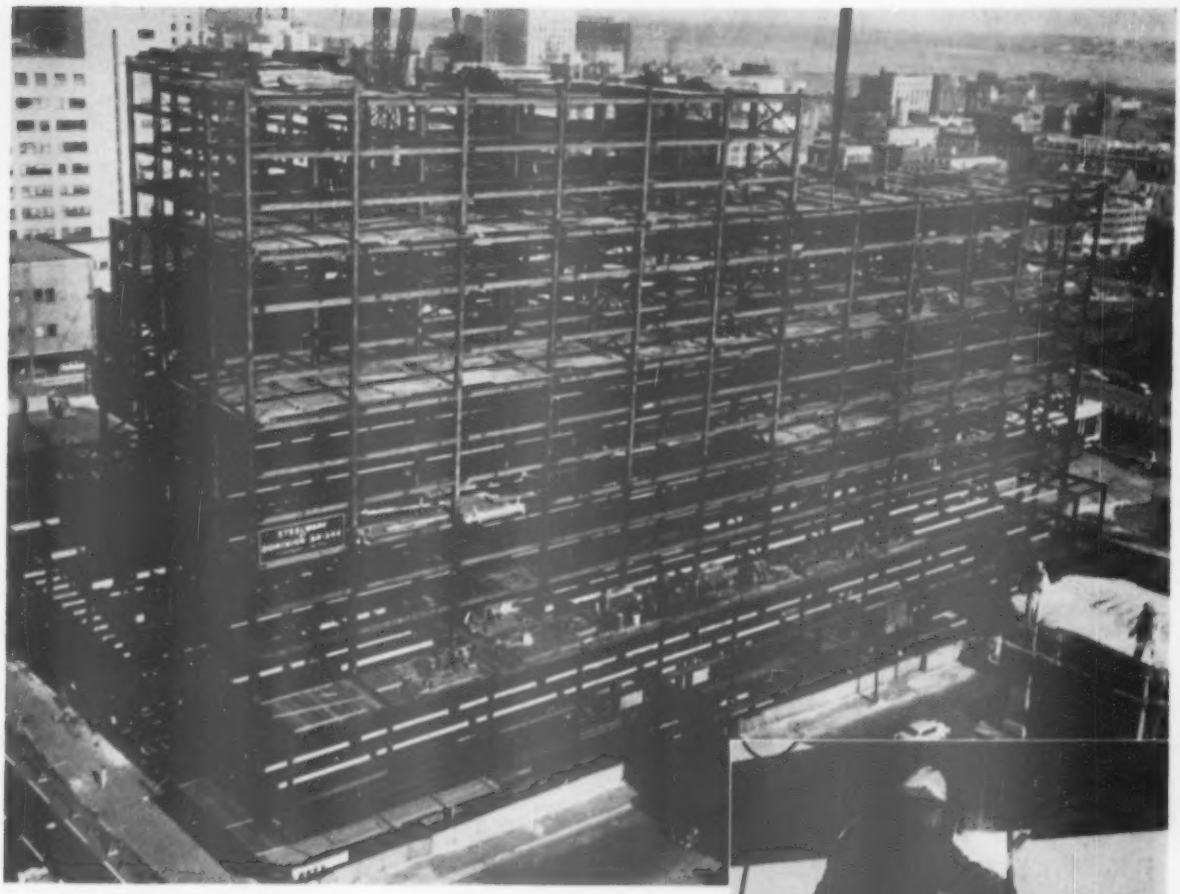
Blackburn, G. H. (C)
Ferree, J. A. (C)
Graf, William R. (B)
Unger, Robert W. (B)

PORTLAND

Coleman, Fred K. (B)
Franklin, Reno (B)
Hill, Jack E. (B)
Pfeifer, W. J. (B)
Scholz, Verne O. (B)
Svendsen, A. W. (B)
Volkenand, Robert L. (B)

PUGET SOUND

Hollingshead, Cecil I. (C)
Soldano, Nicholas J. (C)
Tellefsen, Olaf (B)



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High up in the steelwork where it's windy and exposed, welding can be a problem. But weldors are enthusiastic about Atom • Arc, not only for its speed but for its ease of operation in all positions and its materially reduced spatter.

Dominion Bridge Company of Canada is using Atom • Arc 7016 iron powder, low hydrogen electrodes* in welding the steelwork for this 21-story hotel. It's Canadian National Railway's new 20-million dollar Queen Elizabeth Hotel in Montreal.

Joining the lighter beams to the heavy columns without preheating called for low hydrogen electrodes. Atom • Arc 7016 electrodes in 5/32" diameters were adopted with the approval of both the weldors and Canadian National's inspectors. Along with the essential advantages of highest physical properties, x-ray quality weld metal and freedom from underbead cracking, Atom • Arc electrodes have a deposition rate much greater than standard 6010 electrodes. Starting porosity is eliminated and moisture pick-up is reduced.

Atom • Arc iron powder, low hydrogen electrodes have become standard on many structural and fabricated equipment welding operations. Find out why Atom • Arc is the first choice of users—write today for complete information. Alloy Rods Company, York 3, Pennsylvania.

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Dwyer, Edward (C)
Jacobs, Robert M. (C)
Johnson, Leslie (C)
Milak, Adam (C)
Stanley, Kenneth M. (C)

SAGINAW VALLEY

Banck, Mark G. (B)
Johns, Robert, Jr. (D)
Le Blac, J. V. (B)
Rimkus, Donald M. (D)

ST. LOUIS

Beste, William B. (B)
Courtois, Norvell (C)
Foster, F. K. (C)
Hasenritter, Delmar (B)
Smith, Barnett (B)

SALT LAKE CITY

Frear, Lawrence (B)
Van Derhoff, W. D. (C)

SAN FRANCISCO

Gilbert, Richard F., Sr. (B)
Lucas, Frank M. (C)
Toler, Millard (B)

SANGAMON VALLEY

Barlow, James B. (B)

SANTA CLARA VALLEY

Fylling, Donald R. (C)

SHREVEPORT

Sovony, F. J. (C)

SOUTH FLORIDA

Britt, Duncan E. (B)
Doppelheuer, J. D. (B)
Scruby, George (C)

SUSQUEHANNA VALLEY

Baer, Harold B. (C)

TOLEDO

Barker, James L. (B)
Braithwaite, Fred T. (B)
Dieball, Dean C. (B)
Morrison, E. J. (B)
Schuller, Edward M., Jr. (B)
Stundon, George W. (B)
Tucker, Clarence E. (B)

TULSA

Lowery, Ervin W., Jr. (C)
Mach, Joe A. (B)

WESTERN MASSACHUSETTS

Perry, Robert S. (C)

WORCESTER

Anderson, Carl A. (C)
Cederholm, Frank H. (B)
Luoma, Thomas E. (B)

YORK-CENTRAL PA.

Steffen, John M. (C)

NOT IN SECTIONS

Anik, Salahaddin (B)
Arze, Elias (B)
Hopkins, Ronald W. (B)
Mattson, Jan C. (C)
Palmieri, Ezio M. (C)
Robb, James L. (B)
Roch, John F. (B)
Saunders, Harold L. (B)
Wagener, Noel T. (B)

Members Reclassified

During the month of February

DETROIT

Broniak, Leonard (C to B)

MADISON

Sell, George R. (D to C)

LOS ANGELES

Gnaux, Jack L. (C to B)
Lica, Eugene T. (C to B)

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Bring a group from your plant; your up-and-coming young men whom you want to train for important posts; your top production men, too. Everyone will benefit through learning more about welding and its influence on metals engineering. May 7-11, 1956.

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Through membership in AWS you keep abreast of the latest developments in welding, welding engineering, welding metallurgy and procedures, by the contacts you make and through its local and national meetings and publications. Investment in AWS membership cost less than your daily newspaper, but brings you tremendous and perpetual dividends, and information on how to produce improved products, increase productivity, and lower production costs through modern welding procedures. Send for descriptive brochure to AMERICAN WELDING SOCIETY, 33 West 39th Street, New York 18, New York.

How Tractor Operators **Save 50% on Parts Replacement Costs**

Build-up and hardfacing with Amsco® Automatic Welding saves money, doubles service life

The operator shown here is depositing Amsco AW-79 . . . to build up cash savings for tractor operators.

By rebuilding and hardfacing with Amsco Automatic Welding, he is adding *double the service life* of the original part . . . at about *half the cost* of a replacement part.

The Amsco "550" Automatic Welder is specially designed for this heavy-duty service. And Amsco AW-79 Alloy Steel Electrodes provide high impact and abrasion resistance.

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American Manganese Steel Division · Chicago Heights, Ill.

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NEWS of The Industry

American Bureau of Shipping Re-elects Green

The 94th annual meeting of the board of managers and the members of the American Bureau of Shipping was held on January 31, 1956, in the Bureau's board room, 45 Broad St., New York City.

Walter L. Green, president, presided and expressed to more than 70 managers and members his appreciation of their attendance.

Mr. Green was re-elected president and chairman of the board of managers.

David P. Brown was re-elected senior vice-president and technical manager of the Bureau. Jerome B. Crowley was re-elected vice-president in charge of finance and administration.

Alfred Blum was re-elected treasurer and Daniel L. Parry was re-elected secretary.

Mr. Green and Mr. Brown are members of the AMERICAN WELDING SOCIETY.

G. E. Distributor Appointed

Kirk-Wiklund and Co., located in Kansas City, Mo., has been appointed as a General Electric welding equipment distributor, according to an announcement by C. I. MacGuffie, marketing manager of the General Electric Co.'s Welding Department.

Territory covered by the new distributor includes the Kansas City area as well as surrounding counties in Kansas and Missouri. They will handle the complete line of General Electric welding equipment, including all types of welders, electrodes, and accessories.

Sellstrom Expands

Sellstrom Manufacturing Co., of Palatine, Ill., manufacturers of industrial eye and face protection devices, have announced the purchase of the Industrial Safety Equipment Division of the Pennsylvania Optical Company of Reading, Pa. All materials, inventories, molds and equipment will be moved to the new and modern plant, which Sellstrom built in Palatine, Ill., less than a year ago.

WELDED SKYSCRAPER

The 20-story Beck Building, newest and tallest office building in Shreveport, La., is the world's first welded skyscraper with a colored aluminum exterior curtain wall. It has an aluminum and blue exterior "skin" over a steel frame of all-welded structural joints (courtesy of Lincoln Electric Co.)

Outlook of Automation in Welding Surveyed by ASTE

The American Society of Tool Engineers has just completed a broad-scale study of "what's ahead in automation." Covering the nation's major metalworking industries—in plants of all sizes—in every geographical region of the United States—it has come up with many findings, including the following concerning production welding:

Slightly less than 15% of production welding operations can be automated, industry feels—the averages, however, ranging from only slightly over 5% for the smallest plants to nearly 25% for the 1000–5000 worker plants. The largest plants figure a bit over 15% of their production welding can be automated. The ratio favoring "automating by purchase of new equipment" as against "automating by modifying existing machines" is about 2 to 1. The big group of 1000–5000 worker plants figures the ratio at close to 3 to 1 as a matter of fact. Highest estimate of modifiable equipment is in the 250–1000 worker group. In these plants it is thought that about half of their potential of 15% automated welding equipment can be obtained by automating welders already on hand.

Among a number of items mentioned as desirable in connection with automation included an automatic seam welder that would load and unload itself and make a pressure-tight joint for freon gas at 96% efficiency.

Harris Promotes Trout and Rasmussen

C. M. Taylor, president of the Harris Calorific Co., of Cleveland, Ohio, has announced the appointment of Ralph A. Trout as sales manager of the Company, and Roy L. Rasmussen, has been appointed assistant to the sales manager.

Mr. Trout has been with Harris since 1949, and has been engaged in covering the Company's Distributors, handling sales training, and doing promotional work.

Mr. Rasmussen, 35 years with Harris, was manager of the Cleveland Sales Branch Office previous to his promotion.

Both Mr. Trout and Mr. Rasmussen are members of the AMERICAN WELDING SOCIETY.

COMING EVENTS

A Calendar of Welding Activity

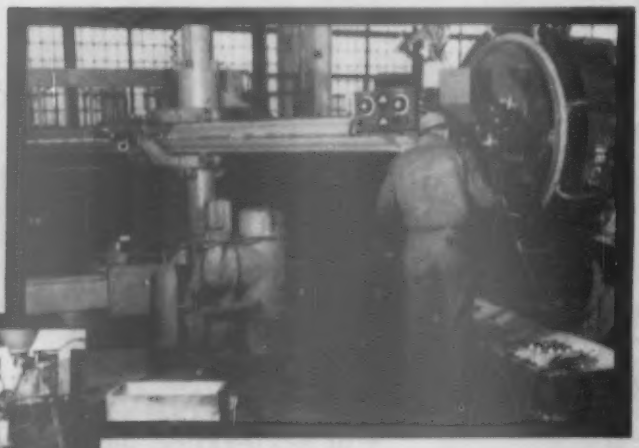
AWS National Meetings

1956 Spring Meeting:
May 7–11, Statler Hotel, Buffalo, N. Y.

Fourth Annual Welding Show
May 9–11, Memorial Auditorium, Buffalo, N. Y.

1956 Fall Meeting:
October 8–12, Cleveland Hotel, Cleveland, Ohio.

Here's a sure way to speed production and CUT YOUR COSTS without complicated and expensive setups



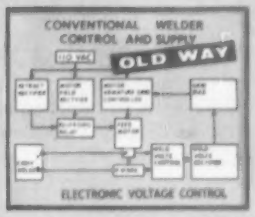
Savings are being made every day for those that go to Automatic Arc Welding. Output is more than doubled in many cases. Higher quality welds become standard with less experienced welders.

More and more plants are turning to automatic and semi-automatic welding operations to lower costs. The big swing to this new and faster welding is due to Hobart's "SIMPLIFIED" method of controls that eliminate elaborate installations and complicated, troublesome electronic and electrical controls.

HOBART Powr-o-matic*

(Constant Voltage) Simplified Automatic Welding

The primary function of automatic welding is to maintain a faster, steadier output of higher quality, lower costs welds. Case histories prove this in actual comparison tests. You'll be amazed how easy it is to use automatic welding (the new way) in your own plant. There are many ways it can be adapted to fit right in with your present production methods without making a lot of major changes. You owe it to yourself to investigate the money saving advantages of automatic welding. Without obligation, why not check the coupon below for more information and see what automatic welding can do for you.



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"One of the world's largest builders of arc welding equipment"

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* ***Powromatic*** is a source of current supply for automatic and semi-automatic welding processes and is of the DC Constant Voltage Type that assures best results and more "Simplified" operation.

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Tell me more about Automatic Welding, using—☐ "POWROMATIC" and "Simplified" Welding Head. How to adapt our present equipment to ☐ Automatic. ☐ Semi-Automatic submerged arc ☐ Semi-Automatic inert gas.

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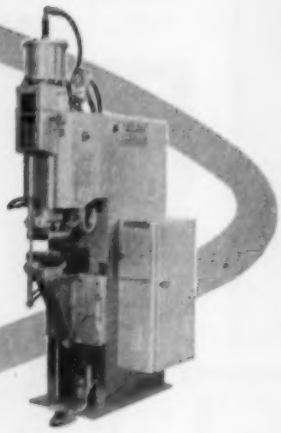
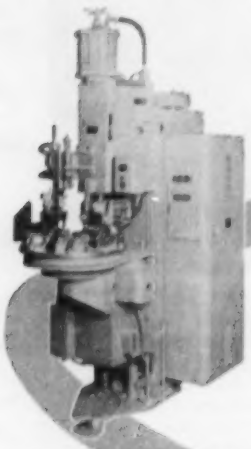
T-W RESISTANCE WELDERS

Standard welders (spot, seam, projection or flash-butt) are versatile. Simple tooling changes enable economical production of different jobs.





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T-W RESISTANCE WELDERS

Welders specially designed for mass production of specific job—lowest total cost per production unit.

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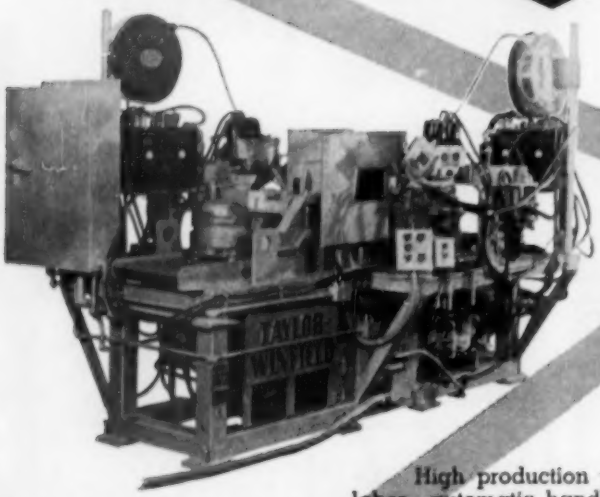

High production with minimum labor—automatic handling, clamping and unloading. All latest fusion welding techniques applied to your problems. Above machine automatically handles and hermetically seals refrigeration compressor housings.

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OAKVILLE AND WINDSOR, ONTARIO

See Us at Booth No. 94
AWS Welding Show—Buffalo

Alloy Rods Distributors Appointed

The Alloy Rods Co. of York, Pa., have announced the appointment of the following distributors to their distributor organization: Allied Welding Co., 808 Linden, Shreveport, La.; Wilson Welding Supply Co., McMullen Highway—U. S. Route 220, Cumberland, Md.; and Edward Fields & Co., P. O. Box 737, Morgantown, W. Va.

Metal & Thermit Opens Seattle Office

Metal & Thermit Corp., has established a sales office and warehousing facilities for the products of its welding division at 2739 First Ave., South, in Seattle, Wash.

Arthur E. Yeoman, sales engineer for the company, who has been located in Los Angeles, has been transferred to Seattle and will be in charge of the new facility.

Stulz-Sickles Co. Celebrates 40th Anniversary

The Stulz-Sickles Co. is 40 years old this year. It was established in 1916, and since 1928 the Company has been directly associated with the welding industry, producing an ever-growing line of manganese-nickel steel products for the reclamation welding of parts worn down through impact and abrasion.

Stulz-Sickles is located at 92 N. J. Railroad Ave., Newark 5, N. J.

Dye Oxygen Expands

Gil V. Dye, president of Dye Oxygen Co., announces the opening of a company branch in Flagstaff, Ariz. The new warehouse and store is located at 117 N. Agassiz St.

Dye Oxygen Co. has other warehouses at Tucson, Phoenix, and Yuma, Ariz., and plants at Phoenix, Ariz.

Mr. Dye is a member of the AMERICAN WELDING SOCIETY.

WELDING SHOW
MAY 9-11
MEMORIAL
AUDITORIUM
BUFFALO, N. Y.

Current Welding Literature

For copies of articles, write directly to publication in which they appear

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PERSONNEL

Beedle Named for Research Award

Lynn S. Beedle, chairman of the structural metals division at Lehigh University, has been named the recipient of the first Research Award of the American Society of Civil Engineers.

The award announced by Enoch R. Needles, president of the society, is in recognition of "experimental and theoretical investigations into the fundamental nature of residual stress in structural steel."

Dr. Beedle, a graduate of the University of California, holds the rank of associate professor in civil engineering. He joined the Lehigh faculty in 1947 following research studies at the Norfolk Naval Shipyard, Portsmouth, Va., and teaching at the Postgraduate School of the United States Naval Academy.

He also is a member of the Welding Research Council, AMERICAN WELDING SOCIETY, Column Research Council and the Society for Experimental Stress Analysis.

Kaiser Joins Thomson

Thomson Electric Welder Co., Lynn, Mass., announces the appointment of Walter Kaiser as assistant chief engineer.

Walter Kaiser

Formerly with the Chrysler Corp. as welding engineer, with Progressive Welder Co. as a development engineer and with Multi-Hydromatic Welding and Manufacturing Co. as chief engineer, Mr. Kaiser has had wide experience in the design and application of resistance welding equipment, automatic feeding and ejection devices and automatic cycling.

Clauser Appointed Editor by Materials & Methods

Henry R. Clauser has been appointed editor of *Materials & Methods*, effective February 1st. He succeeds T. C. DuMond, who has resigned to become a principal in a public relations firm.

Henry R. Clauser

Mr. Clauser, formerly an engineer with American Car & Foundry Co., joined the *Materials & Methods* editorial staff in 1941 and became managing editor in 1950. He served as Lieutenant at the Armor Branch, Ordnance Department, Aberdeen Proving Grounds during World War II. He is chairman of the National Publicity Committee of the AMERICAN WELDING SOCIETY, a member of the Welding Journal Committee, and a past chairman of the New York Section of the AWS. Also, he is active on several committees of the American Society for Testing Materials, and is the author of the book *Practical Radiography for Industry*.

Sullivan Retires

Raymond H. Sullivan, senior engineer of the National Cylinder Gas Co., has retired after 23 years' service. Mr. Sullivan, a native of Sioux City, Iowa, graduated from the University of Michigan and after a short time in Montana returned to Chicago in 1918 where he began his career in the acetylene business with Oxweld Generator Co. and subsequently with Acme Oxy Acetylene Co. He joined National Cylinder Gas Co. in 1933.

He served for many years on committees of the Compressed Gas Association and the International Acetylene Association.

Felbeck Appointed Executive Director

David K. Felbeck has been appointed executive director of the Committees on Ship Steel and Ship Structural Design of the National Academy of Sciences-National Research Council, Washington, D. C. These committees provide advisory guidance for the "Materials" and "Design" research programs of the Ship Structure Committee. Dr. Felbeck takes over the post held by the late Dr. Finn Jonassen who, for many years, directed this work connected with investigations into causes of ship casualties.

A graduate in 1948 of the School of Mechanical Engineering, Cornell University, Dr. Felbeck received his Sc.D. in Mechanical Engineering from Massachusetts Institute of Technology in 1952. He was U. S. Fulbright Lecturer at the Technical University of Delft, Netherlands, during 1952–53.

Dr. Felbeck is a member of the AMERICAN WELDING SOCIETY and a member of American Society for Metals, American Society of Mechanical Engineers, American Society for Testing Materials, Society of Naval Architects and Marine Engineers, Sigma Xi and Tau Beta Pi.

Godfrey Promoted by Harnischfeger

A change in field representation from the Los Angeles Office of the Harnischfeger Corp., has been announced by B. Pratte, general manager, Pacific Division.

William G. Godfrey

William G. Godfrey becomes district manager, Construction and Mining Division with supervision of Welding Division Sales. He was formerly with the Los Angeles office as a specialist in the analysis of customer needs in mining and construction, as well as welding equipment requirements.

Mr. Godfrey is a member of the AMERICAN WELDING SOCIETY.

OBITUARY

Walter E. Palmer

Walter E. Palmer, New York-New Jersey welding engineer for The Champion Rivet Co., died in a traffic accident on the Pulasky Skyway Drive in Jersey City, N. J. on January 26. He was 50 years old.

Mr. Palmer is survived by his widow, his son and two daughters. He was a member of the AMERICAN WELDING SOCIETY for more than 20 years and was very active in the work of the New York Section.

Prior to Mr. Palmer's connection with The Champion Rivet Co., he was associated with the All State Welding Alloys Co. as Sales Manager. Before this he was associated with the Hollup Corp. as Eastern Divisional Manager.

Hugh F. Brown Sr.

Hugh F. Brown, Sr., president of Brown Brothers Welding Co., and president of National Welding Equipment Co., both of San Francisco, passed away in his 71st year on February 3, 1956.

Hugh F. Brown, Sr.

Mr. Brown attended Yankton College South Dakota. He had his first experience with welding in an experimental welding shop at Denver, Colo., in 1910. A year later he was one of the organizers of Metal Weld Co., having moved at that time to San Francisco where he and his early associates built one of the first electrolytic plants. In 1912 his brother Will joined him to form Brown Brothers Welding Co., one of the largest welding shops on the West Coast at that time.

Brown Brothers Welding Co. began to produce gas welding and flame cutting apparatus for their own use, and during the early 20's started to manufacture this equipment also for resale and thus created National Welding Equipment Co.

During the years from 1910 to 1915, Mr. Brown pioneered a successful method of welding marine boilers and did many large and important welding and brazing jobs. With the large welding operations on pipe lines and on the San Francisco waterfront as a background he became a welding consultant on the first welded section of the Mokelumne aqueduct supplying the East Bay cities with water. In 1925 he contracted to weld the first 30 inch pipe line for the Marin Municipal Water District from Alpine Lake. He welded the Bucks Mountain pipe line in Plumas County in 1927 to 1928, and in 1930 he welded the first river crossing for oil pipe lines in Texas. In 1938 he was welding consultant for Sagoc oil pipe lines built in Columbia, South America. The line was 240 miles long.

During all of these years, as president of both of these companies, he contributed materially in the designing and the production of National Welding Equipment Co.'s products. He had a deep interest in the development of the welding industry, both gas and electric, and was among the founders of the San Francisco Section of the AMERICAN WELDING SOCIETY.

...*"it has paid us to use Meco Welding Equipment exclusively for the last 25 years."*

Famous-Barr, Northland Shopping Center, St. Louis

"Our company recently installed the heating, piping and air conditioning for the new Northland Shopping Center—the largest of its kind in this area. As we do on all jobs, we used Meco Regulators and Torches exclusively.

..."we have found that it has paid us to use Meco Welding Equipment exclusively for the last 25 years. Its dependable, durable construction reduces our down-time to a minimum and the men on the job tell me they prefer it to any other make."

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KREMER-HICKS COMPANY

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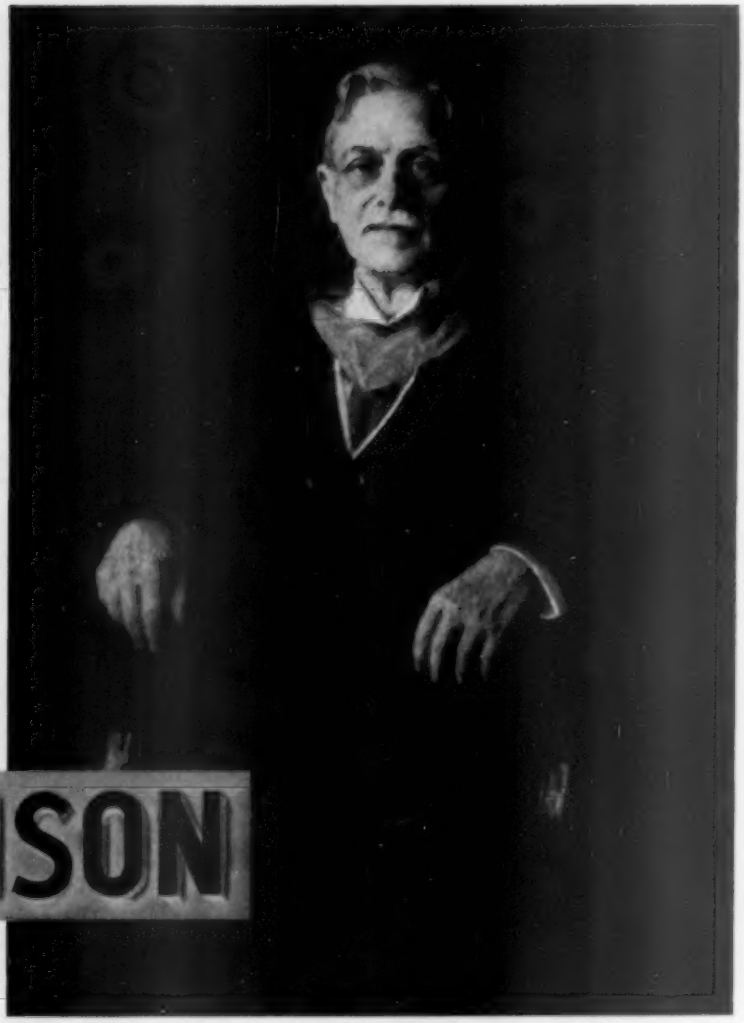


In his lifetime, Elihu Thomson amassed the astounding total of 700 patents, many of which profoundly influenced developments in almost every field of industry.

Perhaps his most notable invention is resistance welding. Basic patents were applied for in 1886 shortly before he founded the Thomson Electric Welder Company.

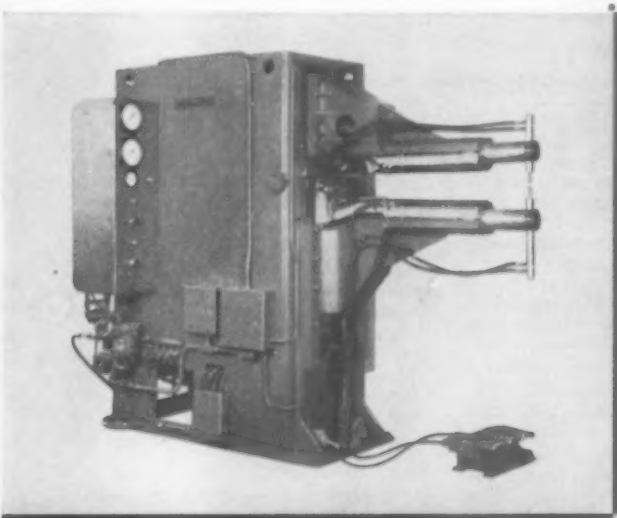
Since then, the Thomson company has continued to pioneer in the development of resistance welding equipment and is largely responsible for making the process the economical and widely applicable production tool it is today. Recent Thomson contributions to the art of resistance welding include:

- Development of high-production standard spot, projection and seam welders.
- "Synchro-Matic" flash welding which opened up entirely new fields of non-ferrous as well as ferrous metal joining.
- Application of automation and precision control to all types of resistance welders.
- Fabric welders, brake shoe welders and other specialized equipment.

Thomson men are strategically located in all metalworking centers. We welcome an opportunity to discuss your resistance welding problems with you.

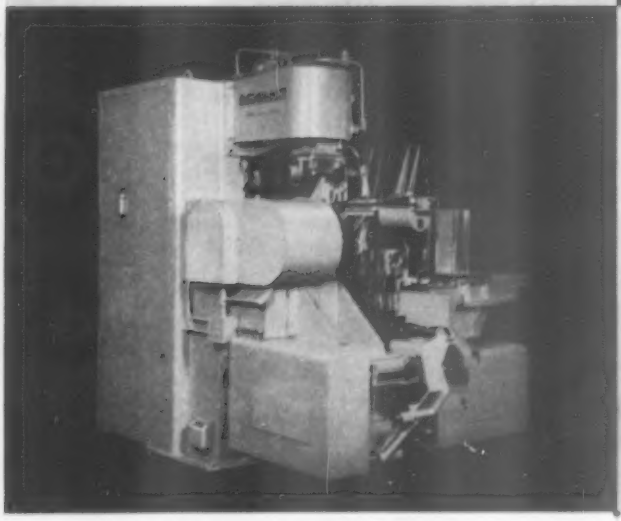
SPOT AND PROJECTION WELDERS

The Thomson line is complete ranging from bench welders to heavy duty presses. The machine shown below is an air operated rocker arm aircraft spot welder.



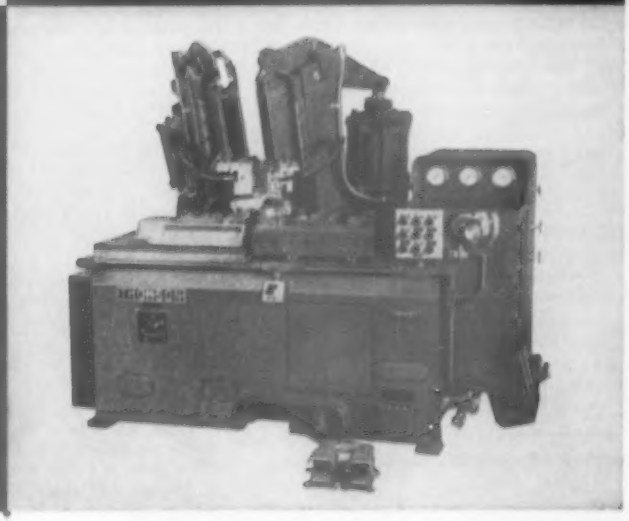
SEAM WELDERS

Sizes range from 50 to 400 KVA including models for circular or longitudinal seaming or universal machines such as the model shown which handles both types.



SPECIAL PURPOSE WELDERS

Many Thomson special designs have become standard equipment in their fields of application. This is a Thomson brake shoe welder with automatic web feed.



"SYNCHRO-MATIC" FLASH WELDERS

An exclusive Thomson development for flash-butt welding ferrous or non-ferrous metals. The Model F3 Synchro-Matic shown is tooled for miter welding window frames.

VISIT BOOTHS 118-119 WELDING SHOW **BUFFALO, N. Y., MAY 9-11**

FOUNDED IN 1886 BY ELIHU THOMSON

INVENTOR OF RESISTANCE WELDING

THOMSON *Welders*

THOMSON ELECTRIC WELDER COMPANY, LYNN, MASS.

ABSTRACTS OF CURRENT PATENTS

prepared by Vern L. Oldham

Printed copies of patents may be obtained for 25¢ from the Commissioner of Patents, Washington 25, D. C.

2,731,709—Method of Making Internally Finned Heat Exchanger Tubes—Hugh L. Gaddis, Cleveland Heights, Glenn W. Myers, North Ridgeville, and Oral S. Welsh, Elyria, Ohio, assignors to Brown Fintube Co., Elyria, Ohio, a corporation of Ohio.

This patent relates to a special process of making internally finned heat exchanger tubes. The novel portion of the invention relates to positioning a plurality of fin members in a confining tube wherein the fin members are held in position around the periphery of the tube solely by contact of base portions of the fins. Thereafter the outer edges of the fins are brazed to the tube.

2,731,932—Welding Clamp—Christian Petersen, De Witt, Neb., assignor to Petersen Mfg. Co., Inc., De Witt, Neb., a corporation of Nebraska.

Petersen's patent is on a special welding clamp including a pair of pivotally related members that have U-shaped jaw elements formed from flat, resilient, metallic material.

2,731,933—Welding Ring—Stanley L. Phillips, Cleveland, Ohio, assignor to Wedge Protectors, Inc., Cleveland, Ohio, a corporation of Ohio.

Phillips' patent is on a welding ring of a special elliptical shape. The welding ring is adapted to be used in welding together beveled end portions of a pair of pipes forming a right angled joint, for example.

2,732,227—Welded Enclosure for Expansion Joint—Edward W. Kaiser, Chicago, Ill.

This patent is on a special combination involving a pair of endwise spaced coaxially arranged elongated housings and has a pipe in and extending through the housings. Expansion means are interposed in the pipe between the housings. Sheet metal enclosure means are welded to the housings for transmitting tension and compression stresses therebetween.

2,732,229—Welding Pipe Coupling—Gilbert A. Gaum, Louisville, Ky., assignor, by mesne assignments, to National Cylinder Gas Co., Chicago, Ill., a corporation of Delaware.

Gaum's patent is on a welding coupling for connecting the ends of a pair of conduit elements. The coupling includes generally tubular male and female fittings adapted to be connected with the end faces of the conduit elements. The fittings cooperate to define an annular chamber generally surrounding the abutting surfaces of the fittings on a radially inner portion thereof, which chamber is provided to accommodate excess weld metal that may flow inwardly from the weld between opposed spaced radially outer surface portions of the fittings.

2,732,323—Process of Welding and Heat Treating Stainless Steel—George Edwin Linnert, Baltimore, Md., assignor to Armco Steel Corp., a corporation of Ohio.

In this patent, a process is disclosed relating to the fabrication of precipitation-hardened stainless steel articles including aluminum as the hardening alloy. The method includes heating the parts to be welded at a temperature of between 1200 to 1600° F and cooling; resistance spot welding the parts; and thereupon heat-treating the fabricated and welded assembly at a temperature of between 700 to 1200° F and cooling.

2,733,326—Machine for Making Contact-Carrying Member—Clarence E. Tuller, Galion, Ohio, and Franklin J. Hickman, Fort Worth, Tex., assignors to North Electric Co., a corporation of Ohio.

The present patent relates to a machine having a welding electrode therein comprising a disc mounted for rotation about its central axis. Means in the machine rotate the disc through angular increments of a predetermined value with each operation of the machine. Electrode-forming recesses are provided on the periphery of the disc to a total number other than a multiple of the number of recesses in the space through which the disc moves on each angular increment of its movement.

2,733,327—Welding Apparatus—Gustav A. Frojd, Rockford, Ill., assignor to Borg-Warner Corp., Chicago, Ill., a corporation of Illinois.

Frojd's patent relates to electrical contact mechanism for providing means to complete a continuous electrical circuit between the contact mechanism and a workpiece. The mechanism includes a plurality of metallic rollers of electrically conducting material adapted to be held in rolling contact with the workpiece and other means connect the rollers electrically to a point of predetermined electrical potential and including a retainer of electrically conducting material. Other means effect holding of the rollers in rolling engagement with the workpiece.

2,733,238—Means for Retaining Flux on Work during the Process of Submerged Arc Welding—Joseph P. Newbold, Sommerville, N. J., assignor to Worthington Corp., Harrison, N. J., a corporation of Delaware.

This patent relates to means for retaining flux on a workpiece during the welding action. The means include a flexible dam having a plurality of elements mounted adjacent to each other on a flexible shaft. Other means support the flexible dam and connect to the dam on both ends thereof which latter means include at least one magnet adapted to affix itself to the workpiece.

2,733,329—Demagnetizing Method—Alfred D. Esposito, New York, N. Y.

A method of arc welding a steel plate is disclosed in the present patent. This method comprises the steps of generating an electromagnetic field by direct current, which field has a linear axis terminating in point poles. The intensity of the field is controlled and the field is located with its magnetic axis normal to the plate surface and with the north pole touching the plate surfaces. The south pole is positioned remotely from the plate surface. An arc is formed at the plate portion and is moved along the line of desired juncture.

2,733,330—Welder's Workstand—Kirby A. Blewett, Corpus Christi, Tex.

The patented welder's work stand includes a work supporting member and a ground sleeve secured to a base provided for the stand. A conductive contact plunger is slidably mounted in the sleeve and flexible cable means electrically connect the contact plunger to the base. Other means are provided for controlling the contact plunger and providing other desired support action in the stand.

2,734,116—Control System for Electric Welder—Ora M. Rybolt, Lapeer, Mich.

Rybolt's patent relates to an electric arc welder which has a reversible motor for driving a rotatable field rheostat for a generator. A double pole double throw impulse relay switch is provided for connecting the reversible motor to a high electrical voltage output source so that in one position of the relay switch the motor rotates in one direction and in another position of the relay switch, the motor rotates in the opposite direction. A manual control switch is also provided in the circuit connected to the circuit of the relay switch, and a welding electrode holder is provided in such latter circuit.

Alternate actuations of the manual switch causes current to flow through switch operating means for closing the relay switch and effecting automatic polarity reversals of the double poly relay switch, by actuation of the manual switch.

2,734,117—Beam Member—John F. Randall, Detroit, Mich., assignor to Ford Motor Co., Dearborn, Mich., a corporation of Delaware.

This patent relates to a process of manufacturing hollow steel members and comprises forming sheet steel into two separate complementary U-shaped members. The edges of one of the U-shaped members is scalloped and the metal is displaced at the peaks of the scallops a distance substantially greater than the thickness of the metal so that upon assembly of the separate U-shaped members, a series of spaced disconnected welding areas of limited extent are formed. The members are assembled with their edges abutting to form a box-like structure and the members are welded together by passing a large electrical current through the disconnected welding areas.

2,734,118—Method of Electric Welding—Alexander S. Patten, Toledo, Ohio, assignor to The Prestole Corp., Toledo, Ohio, a corporation of Michigan.

Patten's method of welding relates to metal members having different electrical resistance characteristics. The member having the greater resistance has at least one integral protuberance on the face thereof opposing the other member. The welding method comprises applying a clamping pressure and a gradient electric welding heat to the members to cause a softening of the metal of the lesser resistant member in the zone of contact of the protuberance therewith. A predetermined depth of penetration is secured due to the applied pressure to force the protuberance into the metal at the zone and a surface softening of the protuberance metal is also provided so that a welding of the protuberance metal to the penetrated metal of the other member is effected.

2,734,119—Method of Forming and Welding Pins to Metal Parts—Albert F. Pityo, Cedar Grove, N. J.

By the teachings of this patent, a wire is fed longitudinally toward a metal part and the free end of the wire is caused to contact the metal part. Such free end of the wire is welded to the metal part and severing blades are brought to engage the wire and effect a cutting action thereon. The cutting edges of the blades are then spaced from the free end of the severed wire, but used to spread the end of the wire and form a relatively thin outer end thereon.

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2,734,120—Expansible and Contractible Welding Jig—Miles L. Sensenig, Lancaster, Pa., assignor, by mesne assignments, to Sperry Rand Corp., New Holland, Pa., a corporation of Delaware.

This patented jig is particularly adapted for use in the assembling and welding of articles of polygonal cross section. The jig includes a stand, a shaft mounted on the stand and a tubular hub element rotatable on the shaft. Other means are provided for positioning the hub element so that on axial movement thereof, radial movement relative to the rotational axis will also be secured.

2,734,979—Brazing Tips—Robert E. Higley, Clarence, N. Y., assignor to Westinghouse Electric Corp., East Pittsburgh, Pa., a corporation of Pennsylvania.

Higley's patent is on a brazing rod composed of carbon. A portion of the surface of the carbon is adapted to engage parts to be brazed and a coating of aluminum is provided on the remaining surface of the rod.

2,734,980—Electric Spot Resistance Welding Apparatus—Morton B. Millenson, Bayonne, N. J., assignor to M. W. Kellogg Co., Jersey City, N. J., a corporation of Delaware.

This patent is on an electric spot resistance welding apparatus wherein one fixed electrode is provided and the other electrode is movably positioned and has pressure applying means associated therewith for applying pressure loading on work parts positioned between the electrodes. An annular contact member surrounds one electrode and is fixedly positioned, while a longitudinally movable, annular pressure applying member surrounds the other electrode. Means that are operable independently of the electrodes are provided for moving one annular pressure applying member into contact with portions of the work parts to move them into contact with each other.

2,734,981—Arc Drive Control for Rectifier Welder—Harry J. Bichsel, East Aurora, and Martin Rebuffoni, Williamsville, N. Y., assignor to Westinghouse Electric Corp., East Pittsburgh, Pa., a corporation of Penna.

The patented arc welder includes a main

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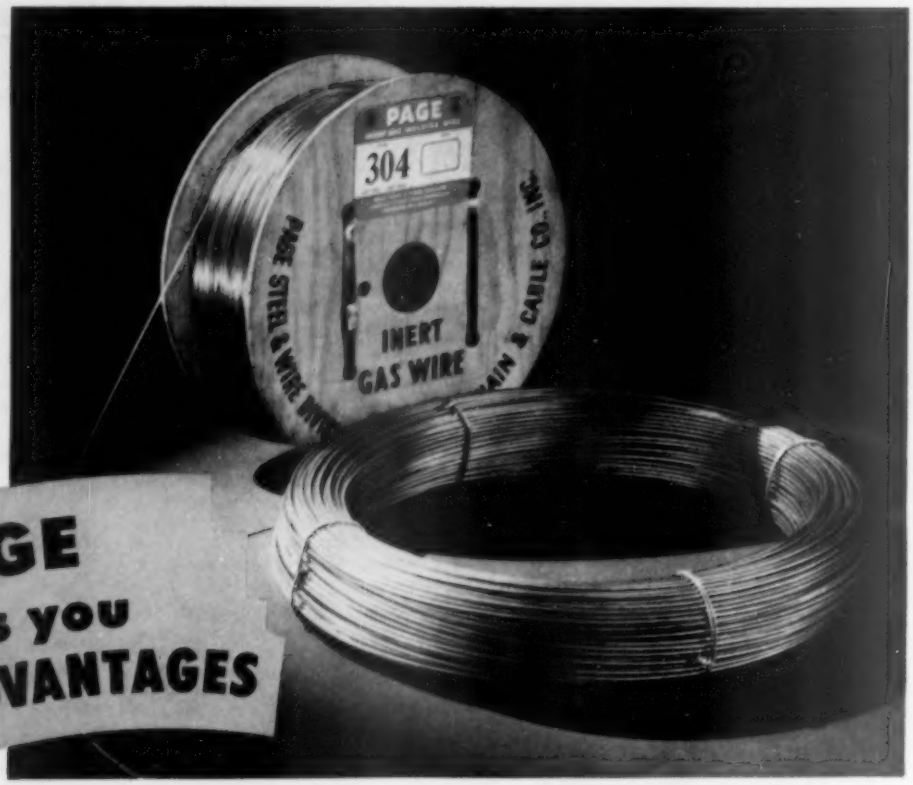

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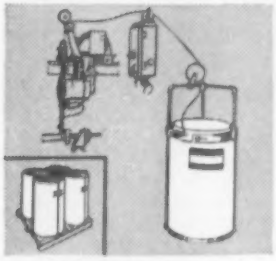

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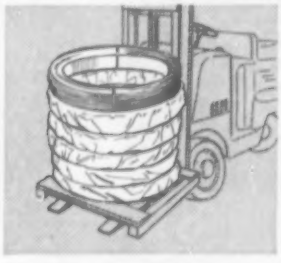
Lightweight and durable, Leverpaks and Pay-off-paks protect against coil distortion or wire corrosion. Compact, easily opened and resealed, roll and stack easily, take little floor space.



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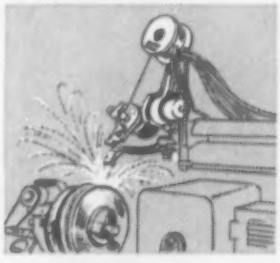
PAGE also offers single and pallet-mounted (1,000 lb., 2,000 lb. and 3,000 lb.) coils, each coil being wrapped in waterproofed paper and secured by steel strapping.



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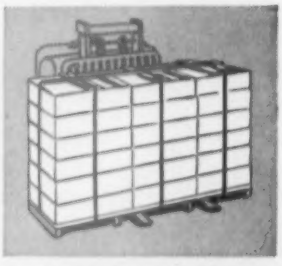
PAGE Inert Gas Welding Wire is available on reels: Precision thread-wound on twenty-five-pound, non-returnable reels to fit all popular inert gas welding machines.



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PAGE Distributors carry ample stocks from which your requirements can be filled without delay or inconvenience to you. This handy service not only saves you time in getting what you need, but makes it unnecessary for you to make a sizeable investment in inventory. Thus, your nearby PAGE Distributor is able to make double savings for you—a saving in time and a saving in actual dollars.

Get the full Analysis List

All the 26 analyses of PAGE Automatic Welding Wire are set forth in complete detail in new Folder DH-402. A free copy of this informative folder will be sent on request. Write our Monessen, Pa., office.

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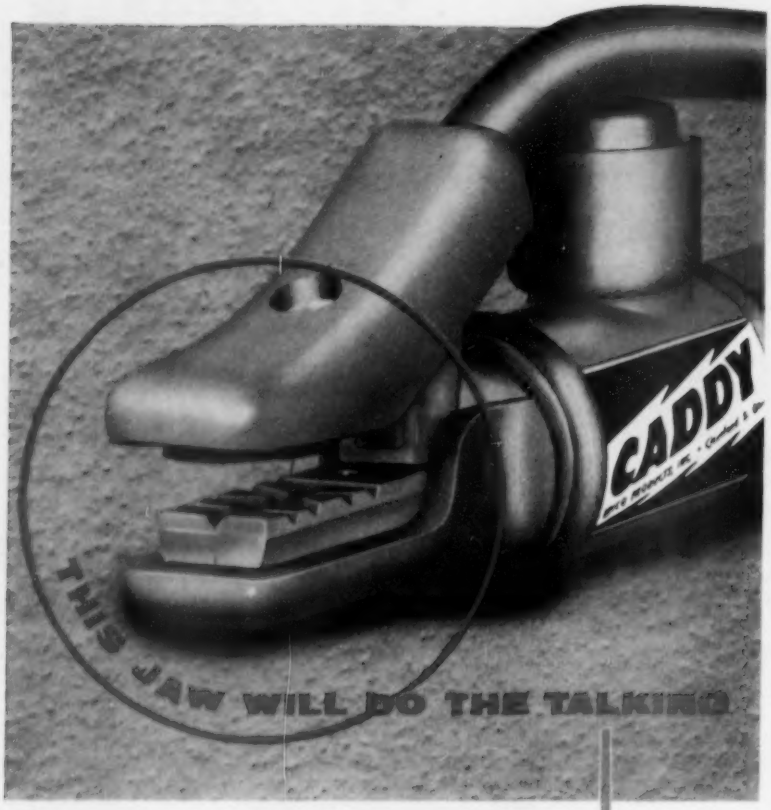

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static rectifier adapted to deliver at its output terminals the normal operating current for welding. Separate current supply means are provided with a lower open circuit voltage than that of the main rectifier. Means connect the terminals of the separate supply to the terminals of the main rectifier and the magnitude of the lower voltage is such that the supply is adapted to become effective when the arc voltage becomes small by reason of the formation of metal threads or the keil during welding. Such lower voltage acts to supply current to blow out the threads before they cause short circuits.

2,735,036—Arc-Welding Apparatus—Charles Volff and Julius Hammerstag, Montreal, Quebec, Canada, assignors to L'Air Liquide, Societe Anonyme pour l'Etude et l'Exploitation des Procedes Georges Claude, Paris, France.

The present patent is on arc-welding apparatus including a torch, a source of welding current, and a source of high-frequency permanently tuned current. The torch is connected to both of the electric power sources and from both of the sources to the ground. A glow discharge tube having two main electrodes is provided, one of which is permanently connected to a part of the torch connected to the high frequency source. Means cause a high-frequency current to pass from the torch to the ground through the tube while substantially preventing the passage of low-frequency current through the tube to cause illumination of the tube by high-frequency current only. The tube diverts a negligible fraction only of the high-frequency current which becomes established across the arc gap after the arc is struck.

BOUND VOLUMES OF 1955 JOURNAL NOW AVAILABLE

Bound Volumes of The Welding Journal for the year 1955 are available in black imitation leather covers, together with a comprehensive subject and authors index. Price $15, including postage.

This volume, comprising a total of 1260 pages in the Journal and an additional 624 pages in the *Welding Research Supplement*, represents a veritable encyclopedia of information in the welding field. Copies may be ordered through the American Welding Society, 33 W. 39th St., New York 18, N. Y.

NEW PRODUCTS

Sonobond Unit

Aeroprojects Incorporated has added another model to their line of "Sonobond" ultrasonic fluxless soldering equipment. This unit is a large hand

model designed to solder or coat aluminum, copper, brass, silver or magnesium. The ultrasonic soldering head has a $^{5}/_{8}$ in. diam soldering tip, readily changeable to other standard or special tips by screw connection. Driven by a 110 R-F watt ultrasonic generator, the soldering head is air cooled for continuous operation. The equipment is designed and built for heavy duty industrial use.

For complete details write above company at 310 East Rosedale Avenue, West Chester, Pennsylvania.

Brazing Rod

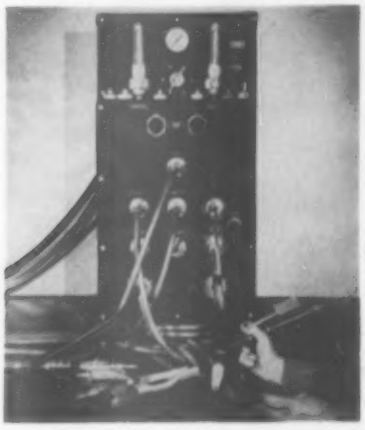
Ampco-Braz No. 1 is a new, nonfuming, high-strength nickel-brass brazing rod of special, "controlled" composition for both joining and overlay with the oxyacetylene process. It is said to bond readily to a wide variety of copper, nickel and iron-base metals and alloys producing deposits silver-like in color.

According to its manufacturer, Ampco-Braz No. 1 is suitable for fabricating tubular steel furniture, instruments, bicycles, etc. where strong attractive brazed joints are required without warpage and distortion. Also, due to high nickel content, it is excellent for depositing tough overlays to combat wear and corrosion. In addition, the deposit provides good corrosion-resistance to many acids, mild alkalies and salt water.

For additional information, write to Ampco Metal, Inc., 1745 South 38 St., Milwaukee 46, Wis. or contact your local Ampco distributor.

Control Unit

Newly developed accessory control unit designed for inert gas (helium, argon and CO_2) shielded arc welds using conventional welding machines is announced by Flexweld Manufacturing Co. of Buckland, Conn. It provides automatic control of torch and



backing gas, torch and fixture cooling water, high-frequency starting spark and welding current. Welding current input may be from: Motor generator—a-c or d-c, Rectifier—d-c, Transformer—a-c or gas-engine-driven machines.

Also features welding current polarity indicator, backing and torch-gas flowmeters receptacles for conventional arc welding, air pressure regulator with air supply fittings, 110-v auxiliary power receptacles. For complete information, write directly to manufacturer, Flexweld Manufacturing Co., Depot St., Buckland, Conn.

Brazing Alloy

"Braze Clad," a product of the American Silver Co., 36-07 Prince St., Flushing 54, New York, is supplied as a ferrous or non-ferrous metal strip clad with a predetermined thickness of silver brazing alloy on one or both sides.

According to the manufacturer, because the prebonded brazing alloy is anchored to the base metal and never relaxes its grip during the heating cycle, there results an even distribution of the brazing alloy throughout the joint area with intimate contact at every point with the metals to be joined. Dependence on capillary creep is entirely eliminated as are voids and oxide islands.

For complete details write directly to the American Silver Co. at the above address.

Safety Goggle

Sellstrom Manufacturing Co., 306 Hicks Rd., Palatine, Ill., announces the production of a new and improved safety goggle which they consider the most fog-free cup goggle now available. It is being manufactured after careful research and experimentation by their Engineering Department.

This No. 421 goggle is reported to have many improvements, including a new feature—a ventilator which is perforated and plated. This gives an abundance of ventilation.

Further information may be obtained by writing direct to Sellstrom.

Temperature Indicators

Tempil® Corp., 132 W. 22nd St., New York 11, N. Y., announces the development of a new Tempil® Pellet for 100° F. Up to the present time the lowest temperature rating for which Tempil® products were available was 113° F because of the problem of storing and shipping lower temperature ratings in the summer time when the climatic temperatures in many parts of the country frequently exceed 100° F.

Shipment of these new low-temperature pellets will be limited to the off-summer months, and if stored during the hot weather they will have to be kept under mild refrigeration.

For additional details write directly to manufacturer.

Automatic Buildup Wire

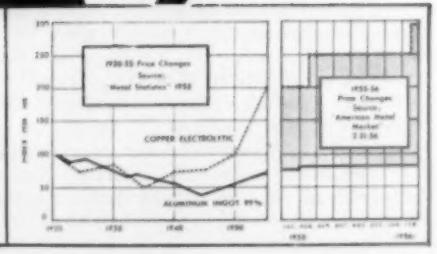
The Air Reduction Sales Co., has announced the availability of a new automatic buildup wire for use with the submerged arc process. According to the manufacturer, deposits are sound with ample ductility and form a perfect bond with a surface hard-facing material such as Airco No. 779. Also, this wire re-

NEW!

Only half the

1 LIGHTWEIGHT to reduce fatigue! Aluminum welding cable is only about one-half the weight of copper welding cable. Thus, it's *twice* as easy to lift and drag around—an important factor in reducing fatigue and increasing efficiency on the job.

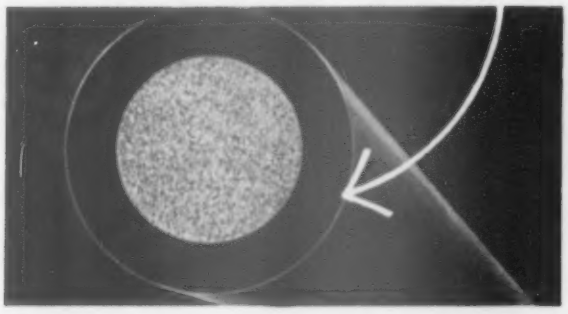
ECONOMICAL! The favorable price of aluminum, when compared to copper, provides important economies. And you continue saving money *even* when you specify aluminum one or two AWG sizes larger than copper to offset its slightly less amperage carrying capacity.



ALUMINUM WELDING CABLE!

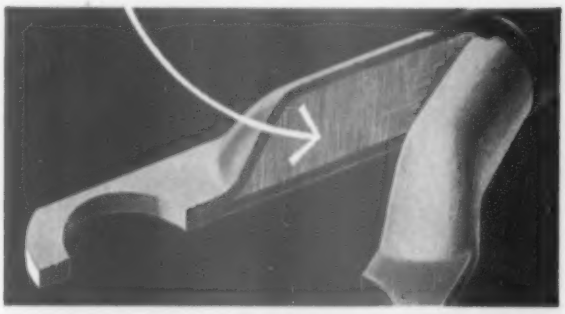
weight of copper cable—plus other important benefits!

2 EXTREMELY FLEXIBLE to make work easier! The fine wires used for aluminum welding cable assure *maximum* flexibility, plus toughness and durability. Aluminum welding cable can easily be looped into a circle with thumb and forefinger—demonstrating the freedom of movement it provides to the welder.



3 DURABLE to withstand hard use! Tough rubber jacket resists abrasion, acids, sunlight and heat. For extremely hard usage, a neoprene jacket is available which offers maximum resistance to abrasion, acids, alkalies, grease, oil, sunlight and heat. In addition, the neoprene jacket is flame-resistant.

4 COOLER to make handling more comfortable! Aluminum welding cable dissipates heat almost twice as fast as copper cable of similar size. As a result, the aluminum cable and electrode holder is far cooler and more comfortable to handle.



5 EASY TO SOLDER for tight copper or brass terminals! Terminal lugs or accessories can be soldered to aluminum welding cable by a simple 4-step method: 1) heat socket or lug barrel with small torch flame, 2) apply non-zinc chloride type flux inside barrel, 3) insert soldering wire while applying heat, and fill ⅔ full, 4) gently work stripped end of cable into solder socket, remove flame, and allow to cool. Connection is then ready for use. Aluminum welding cable also takes good mechanical connections.

Kaiser Aluminum is a leading producer of electrical conductor for transmission, distribution and service drop lines. In addition, Kaiser Aluminum produces building wire and other aluminum conductor products for industry.

At your request, we will be glad to send you our informative folder, "New Advantages in Arc Welding Cable with Aluminum Welding Cable." Write to Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

* * *

To take full advantage of new aluminum welding cable, contact your welding equipment manufacturer or your nearby welding supply distributor. Aluminum welding cable is produced for equipment manufacturers by Kaiser Aluminum at the company's Newark, Ohio wire and cable mill.

Kaiser Aluminum

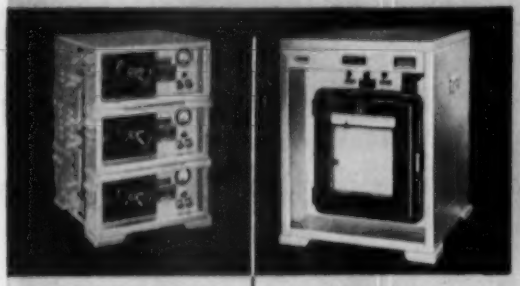
The Smith-Dolan System of
Low Frequency Induction Heating

Model BH

Preheats and Stress Relieves

Easy-to-Operate Equipment for Preheating and Stress Relieving High-Pressure Alloy Steel Weldments

This mobile-type low frequency induction heater, **Model BH**, is a self-contained unit that delivers up to 1600°F for preheating and stress relieving chrome molybdenum and stainless steel. Operators find this equipment easy to use in field or shop, as well as time saving. It's guaranteed to produce thorough penetration in heating large and heavy wall weldments!



Model U-P

This portable, low frequency induction heater offers three-high stack 30 kva - 10 kva per unit. Buy one or stack 2 or 3 units for increased capacity.

Automatic Control Cabinet

Used with Model U-P units (shown at left) and Model GC Duplex 120 or 150 kva induction heaters.

ELECTRIC-ARC INC.

161 Jelliff Avenue
Newark 8, New Jersey

Also available — a complete line of High Frequency Induction Heaters, AC and DC Arc Welders. Write for complete catalog.

sponds to heat treatment and can be applied to all ordinary AISI and SAE steels. It is reported to have high-impact strength and good wear resistance.

The new wire is designed for use prior to final hard facing on parts such as tractor rollers and idlers, earth-moving shovel parts and cable drums. As a buildup with no final hard facing, it is recommended by Airco for the restoration of tractor track rails and links, large shafts, pulley sheaves, mine car and crane wheels.

For more information write Air Reduction Sales Co., 60 E. 42nd St., New York 17, N. Y.

Induction Heating Equipment

Allis-Chalmers has expanded its line on induction heating equipment to include 960, 3000 and 10,000-cycle low-frequency motor-generator units, according to a recent announcement.

Available in sizes from 30 to 1250 kw, the new units are particularly suited to brazing, case hardening, and thorough heating for forging and melting applications.

For additional information write to Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

Gas Shielded Stud Welder

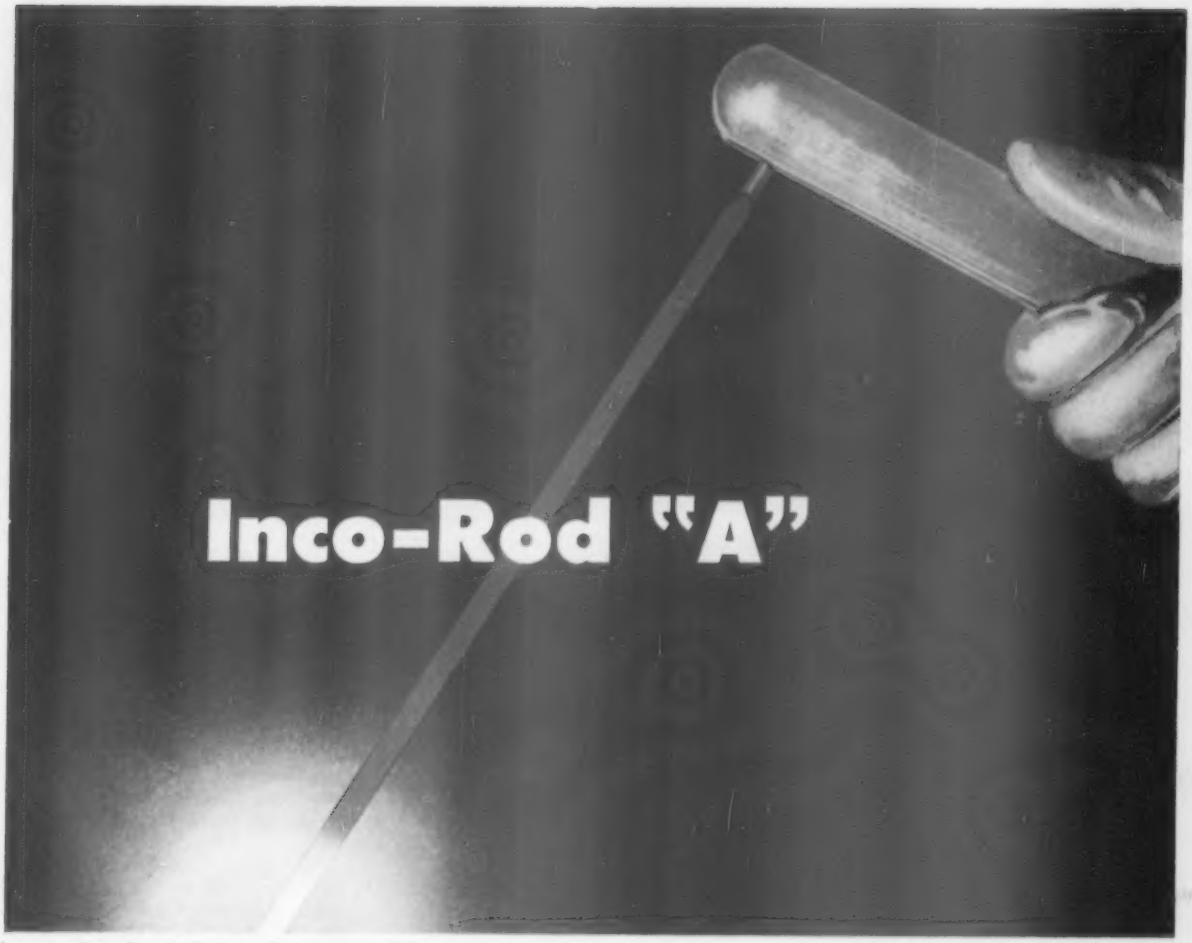
Gregory Industries, Inc., announce that they have been granted a U. S. Patent on an inert gas stud welding gun.

According to the manufacturer, either argon or helium gas is introduced economically through automatic controls which insure consistently good welds on aluminum which are made with about the same speed as that

obtained when end-welding to steel with Nelson equipment.

The fact that the welding area is blanketed with the gas at the time of the weld precludes the formation of aluminum oxide.

For complete details, write to Gregory Industries, Inc., Lorain, Ohio.



INCO-ROD "A" electrode is new . . . different . . . unique!

. . . welds most dissimilar-alloy joints

This versatile, new electrode successfully welds mild steel to 330 . . . 405 to Inconel* nickel-chromium alloy . . . 304 to 410.

More than thirty such combinations have been made between and among ferritic and austenitic stainless steels, low-alloy steels, mild steels, high-nickel alloys, and other types of alloys.

In fact, we expect Inco-Rod "A"* electrode will prove satisfactory for more than 90% of such joints between dissimilar alloys.

This new easy-handling electrode with the distinctive *green* flux coating gives you strong, ductile, X-ray-quality welds. Gives you excellent operability in any position . . . spray-type arc . . . good slag removal! In addition, the impact properties at sub-zero temperatures, stress-rupture properties at elevated temperatures and corrosion resistance will be of a high order.

For welding data on many *proven* combinations of dissimilar alloys, write for the new Inco folder, 'Announcing INCO-ROD "A" '. Be sure to ask, too, about alloys you need to join. New information, constantly coming in from the field, may provide a practical answer to your welding problem.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

*Trademark of The International Nickel Company, Inc.

See Inco's demonstration of NEW welding products.
Visit booths 113 to 115
MEMORIAL AUDITORIUM
Buffalo, N. Y., May 9 to 11, '56

WELDING SHOW

Four handy sizes. INCO-ROD "A" is produced in 14-inch lengths, 4 diameters: 3/32-, 1/8-, 5/32-, 3/16-inch. Packed in 5-lb., tubular, asphalt-lined, protective containers (NEMA color coded).

INCO Welding Products • electrodes, wires, fluxes

■ **can be applied to a wide range of materials**

Mild Steel • High and Low Carbon Steel • Cast Steel • Wrought Iron • Brass • Bronze • Copper • Grey Iron • Malleable Iron Castings.
Chrome and Nickel Cast Irons and many others

■ **easily and quickly applied**

Uniform and Easy Tinning.
Pre-heating or post-heating for stress relief are not necessary.
Low melting point.
Pre-cleaning can be eliminated with certain types of rods.
Bronze welds are easily machined.

■ **bronze welds are dependable in service**

Superior bonding properties • High strength • Excellent wear resistance • Corrosion resistant.

TITAN Bronze Welding Rods are supplied in several types to meet every requirement for oxy-acetylene welding. All are carefully deoxidized to assure ductile, high-strength, non-porous welds. Our general purpose rods are Double-Deoxidized by a patented process.

● *Write Dept. T-66 for complete information*

Quality Alloys by Brass Specialists
BRASS and BRONZE ROD • FORGINGS • DIE CASTINGS
WELDING RODS • WIRE

Titan® METAL MANUFACTURING CO.

Offices and Agencies in Principal Cities | General Offices and Plants: Bellefonte, Pa. ROD MILL DEPOTS: Bellefonte, Pa., Indianapolis, Ind.

Solder-Flux Paste

Just give a light squeeze to the unbreakable plastic bottle and Redi-Mix, a new all-purpose solder-flux paste is ready for instant use to clean, flux and solder all common metals in one quick operation without the need for separate

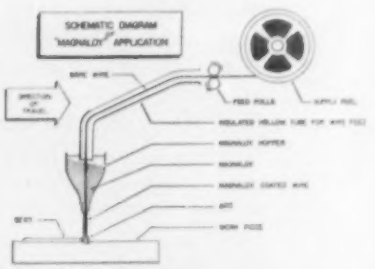
flux and solder. Manufactured by the Anchor Metal Co., Inc., 244 Boerum St., Brooklyn 6, N. Y., the new solder-flux paste is claimed to be the first of its kind utilizing the squeeze bottle and applicator tube.

Write directly to company for full details.

●

Magnetic Alloy Additive

A family of highly-concentrated magnetic alloy additives that supposedly produce high-hardness deposits of extremely high-alloy content faster and requiring less application skill than other methods, have been developed by Western Carbide Corp., North Hollywood, Calif. Designed for semi-automatic or automatic operation, the Magnaloy additives are applied with a dc welder wire feeder, and Magnetic hopper combination.



According to its developers, Magnaloy has the fastest known rate of deposit of any hardfacing material (20 to 40 lb/hr). It may be deposited at a rate of 5 to 6 times faster than hand welding using arc electrodes, and 2 to 3 times faster than other automatic methods.

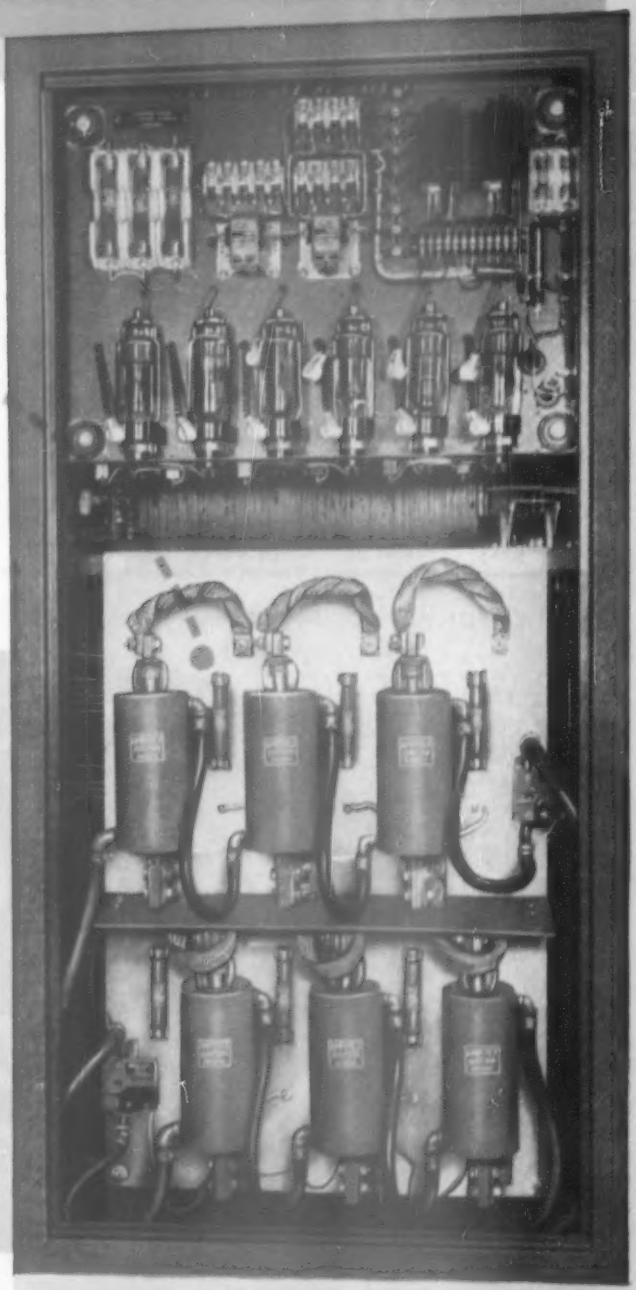
For additional information, write Western Carbide Corp., 6840 Vineland Ave., North Hollywood, Calif.

Amperex IGNITRONS

used by SCIAKY

Heavy-Duty, Three-Phase Welding Rectifier by Sciaky, equipped with Amperex AX5822 Ignitrons

Note convenient and compact installation of the Amperex Ignitrons on rectifier panel, made possible by the heavy, flexible anode leads.



Outstanding features of Amperex IGNITRONS:

- *exclusive "long-life ignitor"— promotes ease of firing and greatly extends length of service*
- *removable, heavy, braided, copper anode lead*
- *visible glass anode seal — simplifies observation of firing*
- *insulating shield around ignitor terminal*
- *rugged stainless and alloy steel construction*

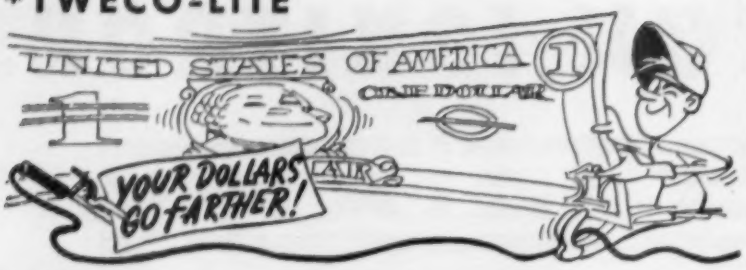
Prove to yourself—
Amperex Ignitrons give lowest "per-hour-cost"

Also Available:
AMPEREX Thermostatically Controlled Ignitrons
Types AX5551A, AX5552A and AX5553B
(No derating necessary for temperature-controlled types.)

Write direct to factory for data sheets and name of distributor nearest you.

Amperex ELECTRONIC CORP.
230 Duffy Avenue, Hicksville, Long Island, N. Y.
In Canada: Rogers Majestic Electronics Ltd.
11-19 Brentcliffe Road, Leaside (Toronto 17)

*TWECO-LITE



Send for FREE CATALOG

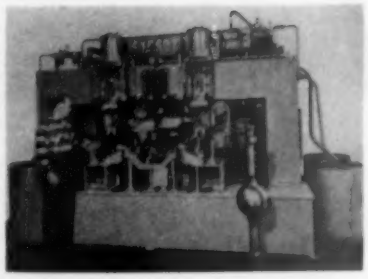
*TWECO-LITE, the new flexible ALUMINUM welding cable that weighs half as much, costs less and lasts longer.

a product of TWECO PRODUCTS CO. Wichita 1, Kansas
Visit TWECO Booth No. 54 at AWS Welding Show

Automatic Welding Machine

A new automatic welding machine that utilizes automation concepts to combine projection welding and carbon dioxide-arc welding in the assembly of two stamped spring support brackets to an automotive rear axle housing is announced by Expert Welding Machine Co., 17144 Mt. Elliott Ave., Detroit 12, Mich.

This new welder, which is said to produce 130 welded assemblies per hour at 80% efficiency, is an in-line transfer-type machine in which the parts are automatically transferred from station-to-station with a mechanism powered by an air motor. Spring support brackets are projection welded for accurate location on the axle housing in the first station. The welded assembly is then moved to the second



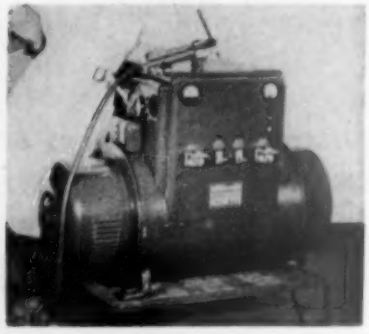
station which is idle and then transferred to the third station where it is rotated by an electric motor drive under four carbon dioxide shielded-arc welding heads to weld the brackets securely to the housing. The finish-welded assembly is transferred to the fourth station where it is deposited on slide rails at the rear of the machine. Locating devices are provided at each station to place the housing in correct radial location for the welding operations.

For complete details, write to the manufacturer at the above address.

Carbon-Air Cutting Machine

"Carbonaire" is a new machine specially designed by Hobart Brothers Co., Troy, Ohio, as a power source for the carbon arc-compressed air method of cutting and gouging all kinds of metals.

The machine is rated 1000 amp., on 85% duty cycle; or 900 amp., on 100% duty cycle, at 36 to 54 v.



The main current ranges are provided by four bus-type cable terminals—one negative and three positive. The cutting torch cable is attached to *low*, *medium*, or *high* current to suit the gouging or cutting job at hand. A convenient hand wheel on the side of the control cabinet is used to adjust the arc voltage to any desired value in any of the three ranges. A toggle switch makes possible the use of a soft start arc if desired. It provides for lower arc starting voltage to reduce the high short circuit current.

For complete details write to Hobart Brothers Co., Hobart Square, Troy, Ohio.

AT THE FRONTIERS OF PROGRESS YOU'LL FIND

FOR WELDING AND CUTTING...

IN THE RED DRUM

HIGHEST QUALITY

DUST-FREE

AN AIR REDUCTION PRODUCT

NATIONAL CARBIDE

Write for the name and address of the NATIONAL CARBIDE supplier nearest you.

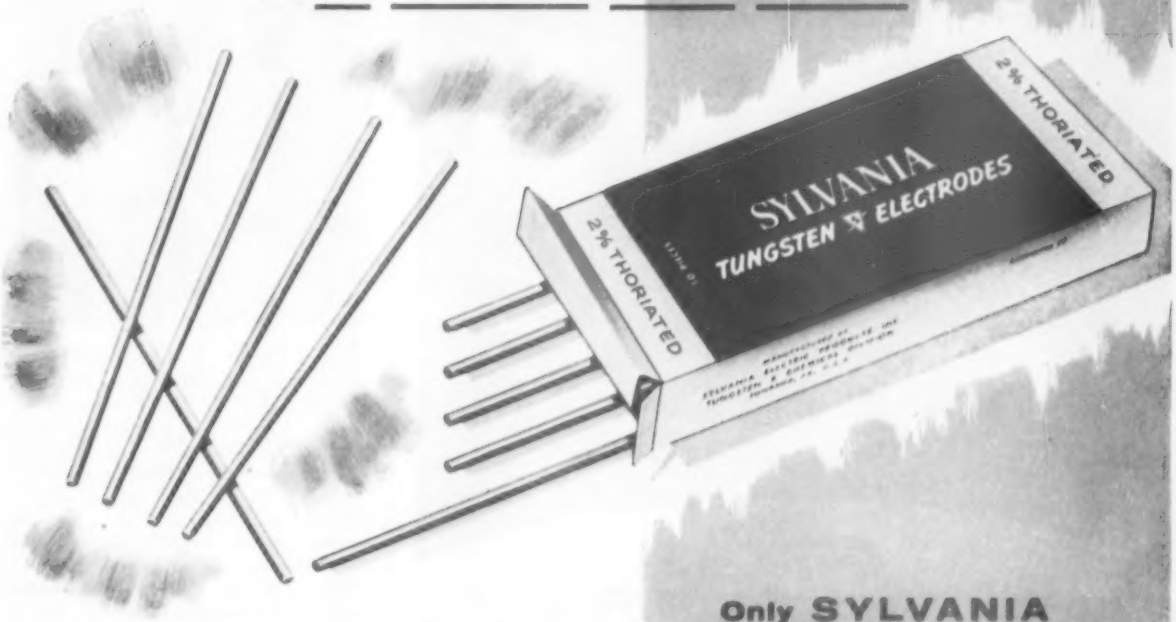
National Carbide Company

GENERAL OFFICES: 60 EAST 42ND STREET, NEW YORK 17, N. Y.

A DIVISION OF AIR REDUCTION COMPANY, INCORPORATED

They're here!

NEW 2% THORIATED
Sylvania Tungsten Electrodes
...at lowest cost ever!



If tungsten inert gas welding is one of your shop's operations—here is good news for you!

Sylvania's new 2% Thoriated Tungsten Electrode is here . . . *at a lower price than you have been accustomed to paying for similar electrodes.*

For specific applications Sylvania 2% Thoriated Tungsten Electrodes give you easier arc starting, more stable arc, higher current capacity, longer life and increased resistance to weld pool contamination.

Remember . . . there is a *right* Sylvania electrode for *every* job. Your Sylvania welding distributor will gladly recommend the correct electrode. Be prepared for any job by ordering some of each type. For technical information, write to:

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada Sylvania Electric (Canada) Ltd.
University Tower Bldg., Montreal, P. Q.

Only SYLVANIA has the complete line of tungsten electrodes–

- **Puretung**
- **Zirtung**
- **Thoriated**
- **2% Thoriated**

SYLVANIA

Lighting • Radio • Electronics • Television • Atomic Energy

When welding stainless...and corrosion resistance is a "must"

WELD WITH ARCOS

STAINLESS ELECTRODES

Welds on a catalytic cracking unit such as this are continually subjected to corrosion, pressure and high temperatures. They must be perfect—faulty welds will result in failure and costly downtime. That's why it pays to specify ARCOS Stainless Electrodes. Quality controlled in manufacture, they assure sound weld metal for long-term dependability under continual use and the severest conditions. ARCOS CORPORATION, 1500 South 50th Street, Philadelphia 43, Pa.

Portable X-Ray Unit

A new Norelco MG 260H X-ray Radiography Unit that fits into the trunk of an automobile and is designed specifically for rapid inspection of welds, pipe lines, power plant, ship and aircraft equipment, is available from the Research & Control Instruments Division, North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

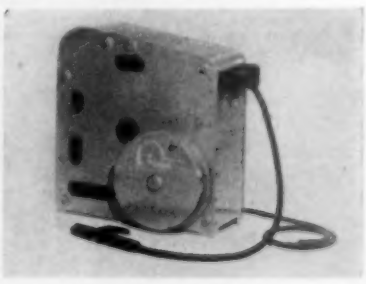
The MG 260H is constructed with the X-ray tube and high tension generator completely enclosed in one unit. Maximum high voltage output is 260,000, minimum is 100,000 and a stepless control permits smooth variation between these limits.

The unit has a focus of 1.5 mm. Tube and generator assembly has a diameter of only 9 in. and is only 41½ in. long. It weighs only 230 lb and is waterproofed for outdoor operation. Design provides a compact unit for efficient handling and positioning, according to manufacturer.

For additional details write directly to Norelco, at above address.

Welding Cable Reel

A new welding cable reel has been announced by United Specialty Corp., manufacturers of welding hose reels. The new model EA handles up to 100 ft of 2/0 cable, at 300 amp. A heavy-duty spring and gear mechanism retracts cable when not in use. Cable may be



locked at any desired length by means of a simple locking pawl arrangement. Construction of the reel permits mounting in any position of the floors, walls or ceilings or on mobile equipment.

For full information, write to United Specialty Corp., P. O. Box 698, El Dorado, Ark.

Automatic Arc-Welding Machines

The Taylor-Winfield Corp., Warren, Ohio, producers of high speed resistance welding machines, now design and construct custom automatic arc-welding machines for increased production of arc-welded assemblies.

The special machinery is designed to include any distribution, handling or positioning required for assembly of arc-welded products or components. Experienced research and engineering facilities are available to study particular needs and develop special machines.

The T-W automatic arc welders use inert-gas-shielded consumable-electrode process, nonconsumable-electrode gas-shielded arc-submerged-arc or submerged-melt process, bare wire or open arc, and other commercial arc-welding processes. The arc-welding machines are useful on carbon and stainless steels, copper, brass, aluminum, magnesium and other ferrous and nonferrous metals and their alloys.

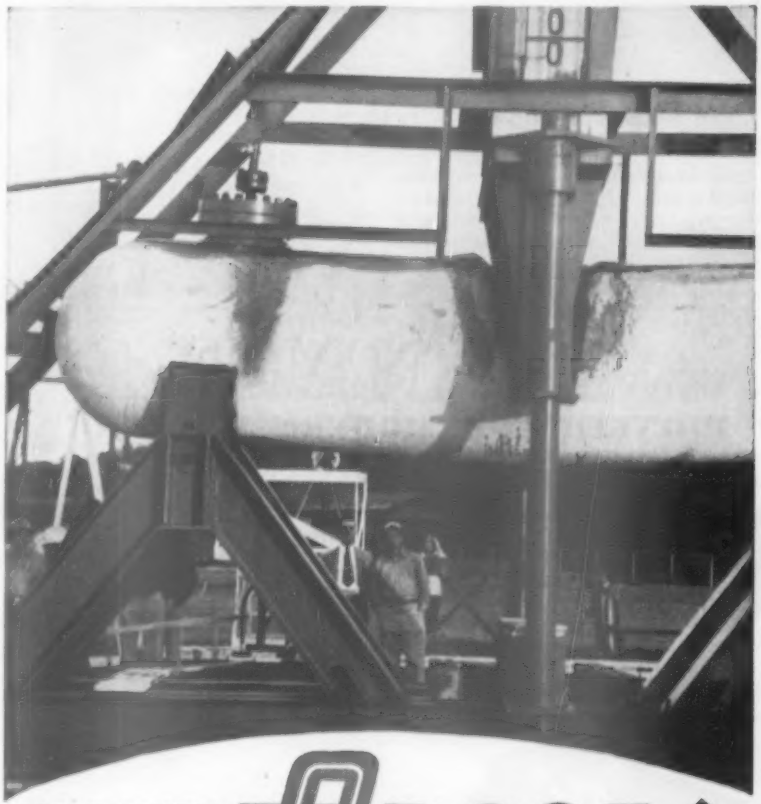
For complete details, write directly to manufacturer.

Inert-Arc Torches

A glass cup for HW-17 torches for inert-gas tungsten-arc welding has been developed and introduced by Linde Air Products Co., a Division of Union Carbide and Carbon Corp. This new glass cup eliminates blind spots by allowing the welder to see the puddle through as well as below the cup used to convey the inert shielding gas to the weld zone.

These blind spots are particularly annoying for such jobs as welding small diameter aluminum and stainless steel pipe. When an HW-17 torch is equipped with the new glass cup, the welder never has to assume awkward or uncomfortable positions to see the molten puddle.

Proof of how to weld Constructional Alloy steels for maximum strength



WELD WITH ARCOS

LOW HYDROGEN ELECTRODES

The above test vessel* was welded with ARCOS Low Hydrogen Electrodes without stress relieving. After being refrigerated to −33°F, and pressurized to 1,875 p.s.i., a 13-ton ingot was dropped on it from 73 ft. All steel and welds remained intact—proof of how Arcos weld metal can meet the severest requirements of strength, low temperature impact, and pressure. ARCOS CORPORATION, 1500 South 50th Street, Philadelphia 43, Pa.

*Made of USS "T-1"—new super tough alloy steel developed by U. S. Steel. Test conducted jointly by Chicago Bridge & Iron Co. and U. S. Steel.

The No. 7 glass cup and its ceramic adaptor is now available for HW-17 torches. The glass cup and adaptor are attached to a torch in the same manner as a conventional ceramic cup.

For complete details write to Linde at 30 East 42nd Street, New York 17, N. Y.

Force Gage

A Force Gage, designed to make dynamic measurements on a recording oscillograph of the force changes between the electrodes of resistance welding machines, is available from Sciaky Bros., Inc., 4915 W. 67th St., Chicago, Ill.

This unit is the strain-gage type, mounted on a cantilever beam of non-

magnetic materials. One end attaches to the horn of the lower arm, and the other end mounts on the front of the machine base plate. Thus, the relative working position of this cantilever beam resembles the hypotenuse of a right angle...the lower arm being the horizontal leg and the vertical leg being the face plate of the welding machine. Force is transmitted to the assembly by the motion or deflection of the lower arm, with respect to the machine base plate.

For more complete information, write to above Chicago address, Dept M-7.

BERNARD

PIONEER FOR MODERN WELDING

"Shortstub" ELECTRODE HOLDER

The jaws substitute for stub waste by splicing a 2 inch extension to the length of every electrode.

"Multi-Pic" CONTOUR CLEANER

Delivers FIVE surface cleaning blows with each swing and lasts FIVE times longer than single headed hammers.

"Pro-Clamp" MECHANICAL HANDS

MODERNIZE the fabrication of plates, shapes, rods, bars, pipes, etc. MAKE fitting, positioning, holding, and welding a fast, accurate, inexpensive, one-man job.

See your Local Dealer, or, Write For Bulletins, SS-6-MP-7-PCB-6

Mfg. by

BERNARD WELDING EQUIPMENT CO.

10230 SOUTH AVE. N • CHICAGO 17, ILLINOIS

Flux Pot

The Helmco-Lacy Flux Pot, a new unit specifically designed and manu-

factured for warming and controlling brazing and soldering flux, has been marketed by Helmco, Inc.

This new unit is said to prevent underheating with inefficient too-thick flux, and overheating with corresponding dry-out, evaporation and out-of-emulsion flux.

The manufacturer offers literature on request to Helmco, Inc., 7400 W. Lawrence Ave., Chicago 31, Ill.

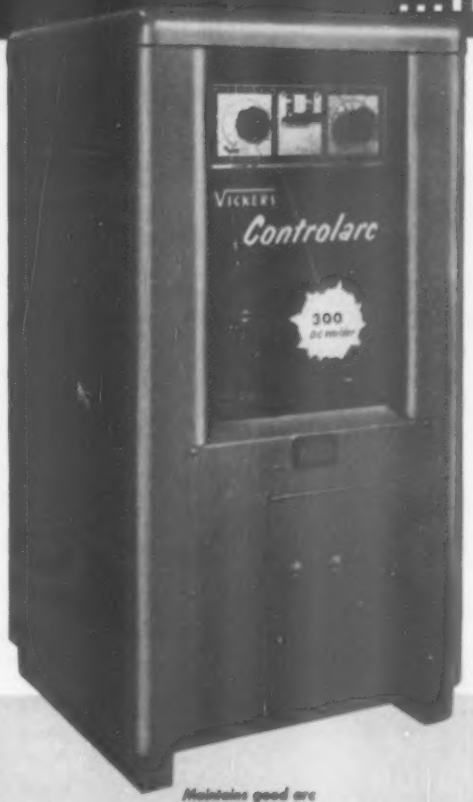
Spot Welder

An economy-priced, air-operated, fully automatic spot welder which welds two pieces of $\frac{1}{8}$-in. steel is announced by Brennen, Bucci and Weber, manufacturers of portable arc welders and band saw blade welders.

Called the Bren/Weld SP-100, it features repeat, nonbeat operation; NEMA-type 1AX timer; a welded structural steel frame enclosed in a heavy-gage steel case; heavy-duty, double-acting air cylinder with adjustable speed control in both directions;

VERSATILITY

...THROUGH ENGINEERING

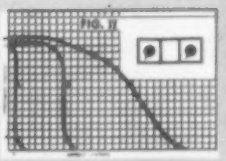


another Vickers FIRST for better welding

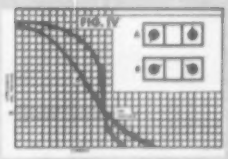
VICKERS

Controlarc DC Welder

1. **Engineered for dependable, long lasting service.**
2. **Covers wide range of welding jobs.**
3. **Excellent in its performance on many critical or hard-to-weld jobs.**

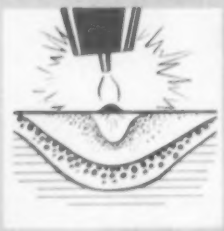


Maintains good arc stability through the complete current range from extremely low to extremely high without range switches.



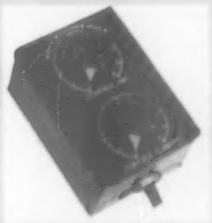
Can bend the volt-ampere curve to meet the particular welding job being done.

Gives complete automatic arc control in any welding position.



Can strike an arc without the use of high frequency when using inert gas and tungsten at extremely low currents.

Exclusive, patented Magnetic Amplifier combines fine control with ruggedness and durability.



Exclusive dual remote control equipment available provides close control of complete current and voltage ranges.

WRITE TODAY for complete information and literature on these and other items of versatility such as low spatter performance on special electrodes, etc.

See our exhibit at the Welding Show • Some territories open for qualified dealers. Write for details.

VICKERS ELECTRIC DIVISION

VICKERS INCORPORATED a unit of Sperry Rand Corporation

1853 LOCUST STREET • SAINT LOUIS 3, MISSOURI

HOW TO

use and apply alloys and fluxes for Soldering, Brazing and Welding Aluminum and Aluminum Alloys

WORLD'S ONE AND ONLY COMPLETE LINE
ALUMINUM

Handiest Pocket Reference is designed Particularly to service operator needs Brief • Direct • Available on Request

This small folder is for the man at the torch or welding machine . . . will help him recognize the alloy made especially for the job he has at hand . . . will refresh his knowledge of exactly how to use it. FREE! Single copies or sufficient numbers to supply weldor crews.

All-State WRITE WIRE PHONE FOR YOUR COPY

TWO NEW SOLDERS FOR JOINING ALUMINUM TO OTHER METALS

105 **Medium Temperature Solder** Good for 18,000 psi Shear. This low cost silver solder requires no more than 750 F. for joining wide range of ferrous and non-ferrous metals.

107 **General Purpose Silver Solder** Stronger—20,000 psi shear—and requiring only 600 F. Like 105, good for aluminum, copper, brass, stainless steel, etc.

Your A-S Distributor Now Stocks Both 105 and 107. Ask to see what problems they can solve for you.

ALL-STATE WELDING ALLOYS CO., INC., WHITE PLAINS, N. Y.

SPA-FLA *Gives you . . .* WELDING PROTECTION *and* SAFETY!

Trade Mark Reg. Pat. Applied for

UL APPROVED

LOW COST-PORTABLE SAFETY WELDING SHIELD

Here is lightweight portable welding shield that is flexible for shaping around even the most out-of-way welding areas, and yet is ruggidly constructed for long hard use.

ON THE JOB-PORTABLE WELDING PROTECTION

SPA-FLA PROTECTIVE PRODUCTS

Welding Curtains, for all booth and production welding protection.

PROTECTIVE COVERS

Asbestos Heat Curtains, fabricated into fire blankets, covers, curtains, etc.

SPA-FLA with RAY-TEX the new Industrial Protective Aluminum Coated Fabric.

SPA-FLA SHIELD AS PART OF YOUR WELDING CART

The last word in welding and safety and portability is SPA-FLA as part of your on-the-job maintenance welding cart. SPA-FLA is easily carried from job to job, and should be the safety habit of every maintenance welder.

TROMMELL Industries

Box 165-J, Dubuque, Iowa

SEE OUR COMPLETE DISPLAY AT THE WELDING SHOW — BOOTH NO. 111

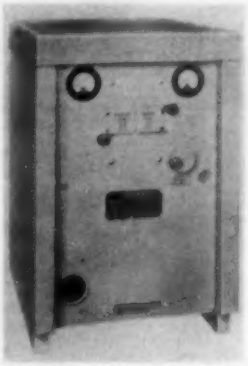
welding horns which can be moved in and out and rotated 360° for maximum versatility. Controls are mounted on a single, side panel for convenience.

Additional details may be had by writing to Brennen, Bucci and Weber, 262 Mott St., New York 12, N. Y.

•

Constant-Voltage Welder

Designed for light consumable-electrode inert-gas arc welding, a new 300-amp constant-voltage power source is now in production by the Glenn Co., Oakland, Calif.



Built-in rectifiers deliver d-c welding current. Arc voltage range is 16 to 42 v, and remains constant at the pre-set value, permitting constant wire feed rate for uniform deposit regardless of variations in arc length due to poor fit-up, etc.

Input is 3-phase, 208 to 250 or 416–480 v ac. The unit carries a continuous-duty rating of 300 amp at 40 v. Efficiency and power factor are 85% or better; input is only 40 amp at 230 v or 20 amp at 460 v, at rated output.

Complete information will be supplied on request by the Glenn Co., 3134 E. 10th St., Oakland 1, Calif.

over 1,000
SPECIALIZED WELDING GUNS FROM ONE PROGRESSIVE STANDARDIZED MODEL

Both Progressive guns in the above illustration have the same chassis—the difference is in the interchangeable cylinders, jaw extensions, electrode adapters, and tips.

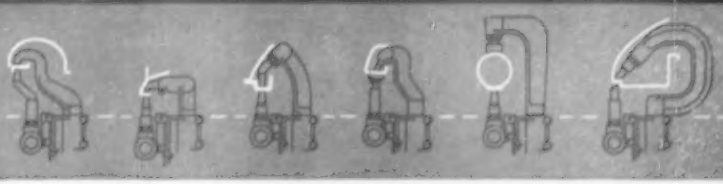
Using Progressive's original Standardized Chassis and interchangeable parts, job-specialized portable welding guns can be made for a fraction of the cost of specially-designed guns.

Progressive has more portable guns in use than all other manufacturers combined. For information on any type of Special or Standard Portable Gun—write to Progressive in care of Department G.

The PROGRESSIVE Welder Sales Company

915 OAKLAND AVE. • PONTIAC, MICHIGAN

Group of special jaw designs demonstrating wide versatility of Progressive Welding Guns.



NEW LITERATURE

Temperature Indicators

The Tempil® Corp., 132 W. 22nd St., New York 11, N. Y. announce the availability of "Temperature Rise Problems?", a reprint of a concise, one-page article which covers the use of Tempilaq® as a temperature indicating means. The article quotes users' descriptions of characteristic applications in development and manufacturing operations. While the examples have been chosen from the electronic equipment field, they are broad enough in scope to suggest many similar applications in other industries.

Write directly to the company for your copy.

Fluxing Procedures Manual

A new American Platinum Works Manual, "A Complete Guide to Selective Fluxing for Low Temperature Silver Brazing," has just become available. It is intended as a useful guide for the correct selection of flux based on specific temperature ranges and metals to be joined. A complete Flux Selector Chart is included in the manual for this purpose.

The applications and characteristics of APW Fluxes are thoroughly outlined in the booklet.

The manual is bound in a convenient pocket size. It is available upon request to: The American Platinum Works, 231 New Jersey Railroad Ave., Newark 5, N. J.

Resistance Welders

Sciaky Bros., Inc., 4915 W. 67th St., Chicago, Ill., introduces Bulletin 316–7, completely describing the Sciaky Type MP 1 Air Operated, Press Type, Single Phase Seam Welder designed to cover a wide range of commercial welding applications.

This brochure fully describes the machine and is supplemented with illustrations together with dimensional drawings. Machine data are tabulated to indicate kva range, throat depths, welding capacities, etc.

For more complete information, write direct to the above Chicago address, Department L-6 for your free copy of Bulletin 316–7.

Arc Welding of Aluminum

A new Information Bulletin which deals with all the electric-arc-welding processes applicable to aluminum has just been released by The Aluminum Development Association of London, England. This is a bulletin on practice, not intended directly to satisfy the needs of those concerned with metallurgical principles. The text distinguishes between the older processes, requiring flux in order to remove the natural oxide film on aluminum, and the more recently developed inert-gas shielded-arc methods which obviate the use of flux.

This 96-page booklet covers a complete discussion of the weldability of aluminum alloys by the various arc processes.

The price of this booklet is two shillings and sixpence and may be purchased directly from The Aluminum Development Association, 33 Grosvenor Street, London, W.1, England. Ask for Information Bulletin No. 19, "The Arc Welding of Aluminum."

Brazing Book

The British Welding Research Assn., in conjunction with their lectures on "Increasing Productivity," given throughout Great Britain, is producing a series of special booklets on welding processes for industry. The Association is enabled to do this through financial assistance from American Funds supplied through the Department of Scientific and Industrial Research.

The first booklet published in this series is on "Brazing." The latter is a modern production technique and is in the vanguard of modern cost-reducing methods. The booklet is directed not only to the designer or production engineer but to the shop floor, and informs the reader of the potentialities, methods, advantages and disadvantages, design considerations and practical points of this process.

In the production of this booklet particular care and thought have been given to the inclusion of the maximum of useful information with the minimum of technicalities, and with economy of words.

It consists of 32 pages of text and illustrations; size $7^1/_4$ x $9^3/_4$ in., price 5*s*.0*d*. each. Order from British Welding Research Assn., 29 Park Crescent, London, W.I.

Brazing Machines

The Selas Corp. of America, Philadelphia 34, Pa., announce that copies of their new bulletin 81050 entitled "Production Brazing and Soldering" are available without charge. For your copy, write directly to Selas.

Safety Products

The Glendale Optical Co., Inc., 600 West Merrick Road, Valley Stream, Long Island, N. Y., announces the availability of their latest catalog on industrial safety products, including welders' goggles. For your copy, write directly to company.

Cast Iron Repairs

A new, fully illustrated four-page booklet entitled, "The Repair of Cast Iron Parts," has recently been issued by the International Nickel Co., Inc. It outlines the latest information on the welding of cast iron with Ni-Rod and Ni-Rod "55." Nine graphic case histories show the welding electrodes in action.

The booklet is available without charge through the Readers Service Section of the International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Process Piping

Information of interest and value to those associated with the fabrication and installation of process piping is contained in a new folder on welding issued by the Tubular Products Division of the Babcock & Wilcox Co. This folder provides information on the welding characteristics of both austenitic and ferritic types of stainless steels and briefly describes various welding methods and techniques. Also included is a table indicating electrodes, preheating and post welding heat treatments to be used in joining the stainless steels to each other and to carbon, carbon molybdenum and chromium molybdenum alloy steels by the arc welding method.

Known as TDC-162A the folder is available free, on request to the division's sales offices at Beaver Falls, Pa.

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A new catalog describing the Pureco CO_2 supply systems for use in the welding industry is now available.

Complete information is included covering the gas flow obtained from each unit. Typical welding applications are illustrated.

Request a copy by writing Pure Carbonic Co., a division of Air Reduction Co., Inc., 60 E. 42nd St., New York 17, N. Y. Specify form ADPC-26.

REVIEWS
OF NEW BOOKS

Piping Design

Design of Piping Systems, Second Edition, by members of the Engineering Departments of the M. W. Kellogg Co. Price $15.00. 365 pages, profusely illustrated. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.

This book covers the entire subject of structural design of piping, with emphasis on flexibility analysis of critical systems. It includes a most complete and detailed treatment of the thermal expansion problem. It also shows how this treatment is extended to calculating the effects of uniform loading, such as that due to weight or wind.

Design Manual

Design Manual for High-Strength Steels, by H. Malcolm Priest, with the collaboration of John A. Gilligan, United States Steel Corp. 174 pages, 41 illustrations, 24 tables. Spiral binding. Published by United States Steel Corp., 525 William Penn Place, Pittsburgh 30, Pa.

Manual discusses the essential principles of structural design and gives formulas, charts and tables which will assist engineers in designing for high-strength steels. It is not intended as a textbook but, rather, as a practical working handbook.

It covers high-strength steels, design considerations for high-strength steels, working unit stresses, tension, compression, shear, stresses in beams, deformation and deflection, formed sections, designing against corrosion, and a very elaborate appendix.

Oxyacetylene Welding

Oxyacetylene Welding, Fourth Edition, by Morgan H. Potter, Marquette Mfg. Co., Inc. Price $2.50. 140 pages, 120 illustrations. Published by American Technical Society, 848 E. 48th St., Chicago 37, Ill.

A practical text and manual on oxyacetylene welding, hard surfacing, lead burning and cutting. Based on actual shop practices, the contents and the scope are of value not only to the apprentice but also the man with wider experience.

Book includes chapters on oxyacetylene process, technique of oxyacetylene welding, welding for different metals, steel welding, cast-iron welding, welding at vertical and overhead positions, pipe welding, bronze welding process, hard surfacing, silver soldering, oxyacetylene torch, malleable-iron welding, welding white metal or die castings, aluminum welding, copper welding, brass and bronze welding, cutting and lead burning and others.

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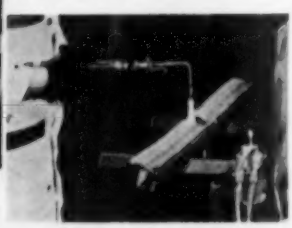

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See your Anaconda distributor for help in selecting the exact rod for your job. Or write for Publication B-13. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Company Ltd., New Toronto, Ont.

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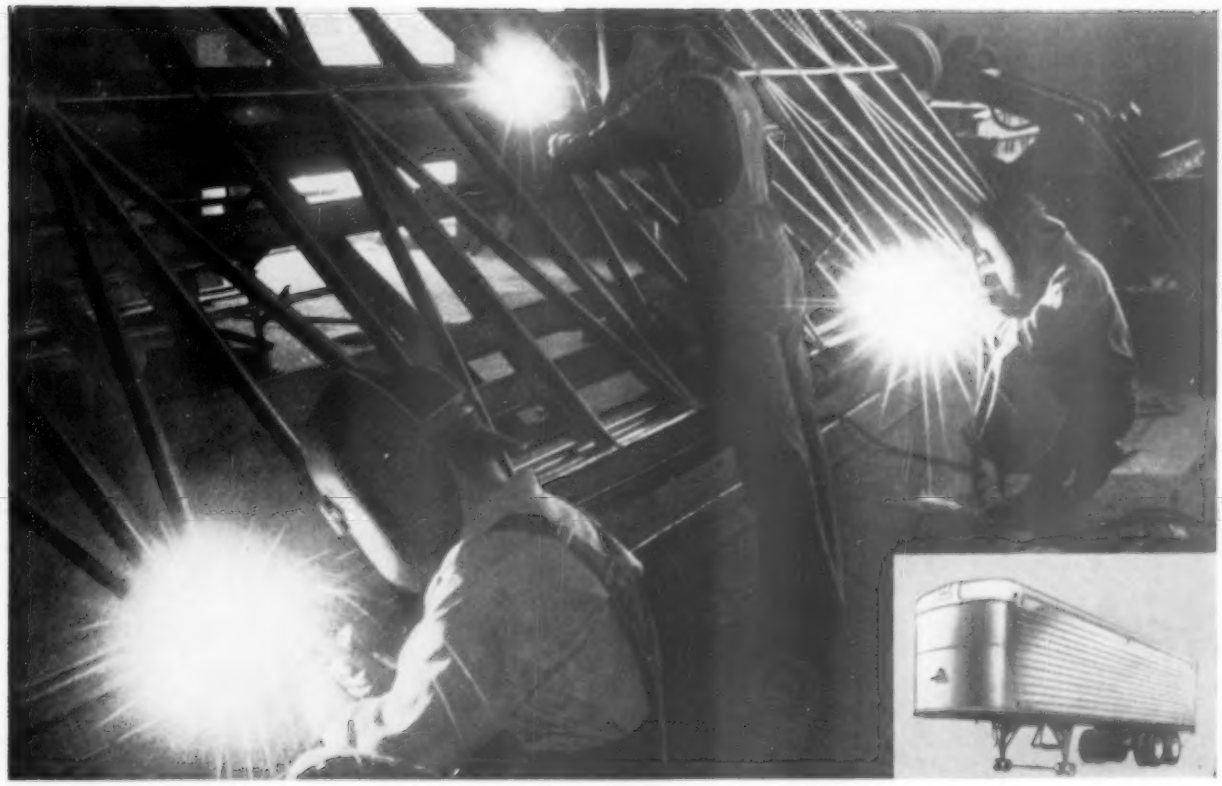

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